The King Review
of low-carbon cars

Part II: recommendations for action

KING REVIEW

March 2008

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HM Treasury contacts

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For enquiries about the publication, contact:

Correspondence and Enquiries Unit
1 Horse Guards Road
London
SW1A 2HQ

Tel: 020 7270 4558
Fax: 020 7270 4861
E-mail: ceu.enquiries@hm-treasury.gov.uk

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Foreword by Julia King

The King Review Part I set out a positive message about the challenge for road transport and examined the technology options likely to contribute to decarbonising road transport now and in the future. In five to ten years' time we could be driving equivalent cars to those we choose today, but emitting 30 per cent less CO_2 per kilometre. Towards 2030, reductions of around 50 per cent are achievable, with the largest contribution likely to come from vehicle technologies, including battery-electric hybrids, and small reductions from both lower carbon fuels (including limited introduction of "sustainable" biofuels) and more environmentally aware consumer behaviour. While the challenge is urgent and sizeable, the message from Part I was that substantial decarbonisation of transport looks achievable – in so far as we can predict the technological progress that may be expected over the next 50 years.

In the six months since the publication of Part I, some encouraging developments have occurred. A number of new cars with emissions levels below the proposed EU target of 130g per kilometre have been launched in the UK. The Government's Climate Change Bill is progressing through Parliament, committing the UK to a 60 per cent emissions reduction by 2050. The Department for Transport has announced a review on the indirect effects of biofuels. The Future Leaders Survey, based on the responses of over 25,000 UK university applicants, paints a picture of a generation intensely aware of the challenges facing the planet and keen to see the Government take a stronger leadership role in tackling them, including a stronger regulatory role, although willingness to adapt their personal behaviour still lags their expressions of concern on environmental issues.

The King Review Part II picks up on the challenges in vehicle technologies, fuels, research and development and consumer choices set out in Part I, and makes policy recommendations aimed at ensuring that government, industry, the research community and consumers all contribute to reducing carbon emissions from cars.

Reducing CO_2 emissions from road transport requires action from everyone. Government has to coordinate efforts in an international context and provide the leadership to allocate responsibilities amongst vehicle manufacturers, fuel companies and consumers. It also needs to enforce clear accountability and put in place the policies and frameworks to allow and enable others to fulfil their roles.

It is only in relatively recent times that governments at national and international levels have sought to implement deliberate policy to lead the way in reducing CO_2 emissions from transport and other sectors. Different countries face different challenges in reducing their emissions and there is not yet universal engagement in reducing emissions or consensus about how best to do so. This creates a particular challenge in the transport sector.

However, there are a number of themes running through the policy recommendations made in this report. Firstly the need to set a long-term direction for policy that has CO_2 reduction at its heart, rather than any one method of achieving it. Different technologies are likely to offer the most potential to reduce CO_2 emissions in the short, medium and long term. Good policy should target CO_2 reduction in recognition that the most efficient methods are likely to change over time. This creates a stable framework that can withstand the tests of time and gives the best opportunity to find the most efficient and cost-effective methods of reducing CO_2.

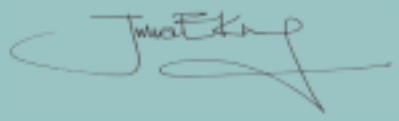
Another theme is the need to ensure new technologies are developed sustainably, taking account of indirect effects, such as deforestation, changing land use and the potential impact of new and exotic materials during both production and disposal. In order to do this we need to develop ways of measuring CO_2 reductions, and indeed broader environmental impact, in terms of life-cycle emissions that take into account both the direct and indirect effects. The recent experience around biofuels development is clearly a lesson here. However, as the conventional internal combustion engine is overtaken by new vehicle technologies and fuels, tailpipe emissions will become a rapidly decreasing proportion of the overall CO_2 emissions and environmental impact of a car, while emissions in upstream fuel production and vehicle manufacture and disposal will be the new focus. Policy must target overall CO_2 emissions to ensure that tailpipe emissions are not reduced at the expense of emissions elsewhere.

A third theme of this Report is the global nature of the effort required. A car may be designed in one country, assembled in a second (often from parts manufactured in many others), sold and used in another and rely on fuels produced in a fourth. In this context, national policy to reduce CO_2 emissions has limitations. It is a challenge to set appropriate policy and regulatory measures within this context, at the right level (national or supranational) and trajectory. If policies are too narrowly scoped, or regulations made too severe, it can have the effect of "shuffling" CO_2 emissions from one country to another, often a less developed country, less able to afford to deal with the effects. The global nature of the challenge is obvious, and the Stern Review concluded that to achieve greenhouse gas stabilisation at 550ppml the developed world must make emissions reductions of 60-80 per cent by 2050, compared with the 2000 levels. Cars currently contribute around 13 per cent of CO_2 emissions in developed countries, one of the largest contributions from a single source after power generation.

Ultimately, the goal should be a global carbon market, which would enable resources to be allocated efficiently. However, in the absence of international consensus, individual countries and clusters of countries must show leadership both in cutting their own emissions and developing international collaborations that can achieve so much more.

In that context, I very much hope that the UK will take on a strong leadership role both in driving European consensus and in national policy, particularly on demand side measures where national policy can be particularly effective.

Many people have contributed to this report. Those who contributed formally to our discussions and thinking are listed in the acknowledgements, and there have been many other valuable contacts at conferences and meetings. Particular thanks must again go to Nick Stern for his advice and comments. Once again I am indebted to the Review Team – led by Kirsten Cownie and Chris Mullin from HM Treasury, and drawn from the Departments involved in this Review, they have provided excellent support throughout and worked effectively and apparently tirelessly to deliver this report. I therefore wish to formally record my thanks to Kirsten Cownie, Liz Hindson, James Hooson, Paul Kissack, Chris Mullin, Adrian Murphy, Mel Rich, Helen Roberts, Will Steggals, Greg Vaughan and James Wright.



Julia King
Aston University
March 2008

Executive summary

Terms of reference

1. The previous Chancellor of the Exchequer commissioned this Review in Budget 2007 "to examine the vehicle and fuel technologies which over the next 25 years could help to 'decarbonise' road transport, particularly cars."

2. *The King Review Part I: the potential for CO_2 reduction* was published alongside the 2007 Pre-Budget Report. The Review initially reported to the Secretaries of State of four Departments – the Department for Transport (DfT), the Department for Environment, Food and Rural Affairs (DEFRA), the Department for Trade and Industry (DTI) and HM Treasury. During the period of the Review, the DTI's role was taken on by two newly formed Departments: the Department for Business, Enterprise and Regulatory Reform (BERR) and the Department for Innovation, Universities and Skills (DIUS). This Review makes recommendations to all five Departments as well as some that concern local government, industry, international bodies and the academic community. It also has messages for all of us, as consumers, about playing our role in reducing CO_2 emissions from road transport.

Introduction

Growth, mobility and environmental responsibility

3. Road transport underpins our way of life. In the century since the first mass-produced motor vehicle, the Ford Model T, was produced road transport has dramatically enhanced mobility, economic prosperity and quality of life for billions of people, as well as becoming a major industry in its own right. In the future, as the economies of the world continue to develop, there is no doubt that road transport use will expand further, bringing with it even greater benefits.

4. In 2000, cars and vans accounted for 7 per cent of global carbon dioxide (CO_2) emissions, a proportion that is rising rapidly as economic growth brings the benefits of widespread car use to the world's emerging and developing economies. Under a business-as-usual scenario, global road transport emissions would be projected to double by 2050.[1]

5. The global challenge is to enable growth in road transport, in a sustainable, environmentally responsible way. Technology has helped achieve radical improvements in vehicle performance and safety in the last century. In the next 25 years the automotive industry will have to address the greatest challenge yet: delivering environmental solutions.

[1] http://www.hm-treasury.gov.uk/media/8/D/Transport_annex.pdf.

The environmental challenge for road transport

6. The Stern Review on the Economics of Climate Change[2] sets out the overall environmental challenge. Globally, as a result of the growing concentrations of greenhouse gases in the atmosphere, climate change threatens severe consequences including flooding, drought, population displacement and ecosystem destruction. The benefits of strong, early action far outweigh the costs. To achieve greenhouse gas stabilisation at 550ppm,[3] emissions reductions (total across all sectors) of at least 25 per cent by 2050 will be needed, relative to 2000 levels. At the 2007 G8 summit in Heiligendamm, an ambition of a 50 per cent reduction in global emissions by 2050 (relative to 1990 levels) was agreed. Stern asserts that the developed world, including the UK, needs to lead the way by achieving total emissions reductions of 60 to 80 per cent by 2050.

7. A challenge on this scale requires all sectors, including road transport, to make urgent and substantial progress in reducing CO_2 emissions.

8. The costs of stabilising the climate are significant but manageable – delay would be dangerous and much more costly. Stern estimates the cost of strong, early action on emissions reductions to be 1 per cent of global GDP per year, compared with 5-20 per cent of global GDP per year in perpetuity if the world fails to act.

King Review Part I findings

Long term, an 80 per cent reduction in UK road transport emissions is feasible

9. The King Review Part I set out a positive message about the potential for CO_2 reduction: that in the long term (by 2050 in the developed world), almost complete decarbonisation of road transport is a realistic ambition. If substantial progress can be made in solving electric or other innovative vehicle and fuel technology challenges and, critically, the power sector can be decarbonised and expanded to supply a large proportion of road transport demand, per kilometre emissions reductions of around 90 per cent could be achievable for cars. If the rate of road transport growth projected by Eddington[4] continues, and road use in the UK approximately doubles by 2050, this would deliver an 80 per cent reduction in total road transport CO_2 emissions, relative to 2000 levels.

Focusing on vehicle efficiency in the short term

10. As well as focusing now on the scientific developments required for the long-term objective of decarbonising road transport, it is important to take immediate steps to reduce emissions in the short term, through the development and implementation of improvements to established automotive technologies. With increasing concern over the real benefits of current biofuels, there is a need to refocus action and investment on the implementation of existing solutions to improve vehicle efficiency – moving low-carbon technologies from the "shelf to the showroom". The King Review Part I assessed that such action could reduce per kilometre emissions of new vehicles by as much as 30 per cent within five to ten years.

11. In the medium term, by 2030, the analysis from the King Review Part I suggests that emissions per kilometre could be around 50 per cent below 2000 levels, implying an overall reduction in UK emissions from car use of approximately 30 per cent by 2030 once the projected increase in distance travelled is taken into account.

This challenge can be met with strong action now

12. This is an urgent and sizeable challenge, but it can be addressed cost effectively with strong action now. Even in the short term, we can achieve significant reductions in CO_2 emissions through the use of technologies that are already available, and by making smart choices, as individuals, about what, when and how to drive.

[2] *Stern Review on the economics of climate change*, 2006.
[3] Parts per million, CO_2 equivalent greenhouse gases in the world's environment.
[4] *The Eddington Transport Study*, 2006.

13. There is no single solution. To achieve this goal substantial progress is needed across the board:

- reducing vehicle emissions;
- cleaner fuels;
- consumer choices; and
- research and development.

14. Actions by government, businesses and consumers are all needed to realise the major opportunities to reduce CO_2 emissions from car use identified in Part I. Action is needed now to realise the short-term potential for cost-effective emissions reduction and to put in place the environment and incentives for the long-term developments needed to decarbonise road transport.

Key Messages of this Review

15. The ambition for the King Review Part II has been to recommend policy and actions, by government, businesses and consumers, to deliver the major CO_2 reductions identified in Part I. Recommendations for the short and medium term are aimed at:

- bringing existing low emission technologies from "the shelf to the showroom" as quickly as possible;
- ensuring a market for these low emission vehicles;
- moving the short-term focus back from biofuels to automotive technology;
- making sure that further biofuel developments are based on our growing understanding of their indirect effects; and
- ensuring the automotive industry has the right requirements and signals to deliver step-change technologies in the medium term.

16. In parallel there are a number of recommendations to enable the UK to play a leading role in low-CO_2 automotive developments:

- as an influential international voice;
- as a location for high technology companies in the field, with good businesses support mechanisms encouraging inward investment, which has the potential to make a significant contribution to the UK economy;
- collaborating with developing and emerging economies to enable them to introduce affordable low emissions technology at the earliest opportunity; and
- as a leader in key areas of underpinning science and engineering for future low CO_2 vehicles.

17. Governments at the local, national and international level have a wide range of policy levers at their disposal, including fiscal policy, regulation, public procurement, information, R&D support, public transport policy and wider government policy. However, a car may be designed in one country, manufactured in another, sold and driven in a third, and run on fuels from a fourth. Therefore a balanced, targeted package of policies, set in an international context, is essential to deliver the potential CO_2 reductions set out in the King Review Part I in a cost-effective way.

18. As well as taking into account CO_2 impacts, effective policy must have regard to a number of other criteria, including sustainability, cost-effectiveness, macroeconomic impacts, distributional effects, well-being and international priorities. Government can give confidence to industry and consumers by supporting innovation through the implementation of flexible frameworks, based on CO_2 emissions reduction, which can stand the test of time.

Reducing vehicle emissions

19. The King Review Part I established that considerable CO_2 savings (up to 30 per cent) could be achieved in the shorter term, through enhancements to conventional vehicle systems, using technology that is already "close to market". However, both demand side and supply side barriers are currently delaying deployment, despite the fact that many of these changes are likely to represent good economics for the purchaser, as a result of their impact on fuel economy. Voluntary EU agreements on CO_2 emissions with vehicle manufacturers have failed to overcome these barriers. Ensuring these technologies are quickly brought to market constitutes a major policy challenge, but one that will have a major impact on emissions reductions from road transport in the coming years.

20. Part I also set out how cars that emit 50 per cent less CO_2 per kilometre than the equivalent current models could be on the road by 2030, subject to advances in hybrid and battery technologies and industry overcoming cost barriers. Longer term, vehicle technologies that will enable a 90 per cent reduction in per kilometre emissions are feasible. Achieving this, however, is dependent on very low CO_2 power generation.

21. Part II builds on this analysis to set out the policy framework for vehicle technologies and policy recommendations in the following areas:

- setting appropriately stretching near-term targets for all manufacturers to pull through new technologies in a flexible and cost-effective way, including supporting adoption of the EU's proposals for regulation by 2012;
- setting the longer-term trajectory for vehicle technology regulation so that manufacturers can plan and invest effectively for the next generation of cars that could emit 50 per cent less CO_2 per kilometre by 2030; and
- setting the long-term direction for regulation beyond tail pipe emissions to ensure future vehicle technologies are measured against life-cycle emissions and their overall sustainability.

22. Recommendations 1 to 5 in Chapter 2 address these challenges.

Cleaner fuels

23. In the short term, whilst the internal combustion engine remains dominant, the scope for decarbonising fuels (rather than making vehicles more efficient) may be largely determined by the scope to expand biofuels sustainably as other possible low-carbon fuels cannot be widely used in the current vehicle stock. The King Review Part I urged caution in the expansion of global biofuel demand until improved technology and comprehensive sustainability safeguards are in place. Since its publication, concern over the sustainability of current biofuels has increased. Given the significant productive land requirements of current biofuels, it may therefore be difficult to reduce the carbon intensity of fuels by more than 10 per cent over the next 10-15 years without causing significant land-use change.

24. However, in the longer term it is likely that there will be significant scope to decarbonise fuels through using electricity and hydrogen (where low-CO_2 production routes are available) as well as through new biofuels that have very low productive land requirements. By 2050, a carbon-free fuel mix is a possibility – although this is likely to be largely dependent on the degree to which electricity generation can be decarbonised and will also require developments in vehicle technology.

25. Part II builds on the analysis from Part I and sets out four overarching challenges for cleaner fuels policy:

- reducing CO_2 from fuels efficiently, by allowing flexibility for all possible routes to reduce emissions, and ensuring that emissions do not increase through unconventional methods of producing fossil fuels;
- reducing CO_2 from fuels sustainably, including setting a sustainable level of ambition and ensuring more sustainable biofuels are developed;
- ensuring an effective and fair global market for fuels; and
- enabling effective expansion of low-carbon fuels by ensuring that the vehicle technologies and infrastructure requirements are considered alongside fuel developments.

26. Recommendations 6 to 14 in Chapter 3 address these challenges.

Consumer choices

27. Technology achieves nothing if it is not adopted – consumers must be engaged in order to realise fully the potential for reducing CO_2 from road transport. The King Review Part I estimated that savings of around 10-15 per cent could come from changes in consumer behaviour, much of this over the next few years. Small things that can have a significant cumulative impact include:

- demanding new technologies: choosing the most fuel-efficient car in the range or market sector can significantly reduce CO_2 and pull low-carbon technologies through to market. Downsizing vehicles would save much more; and
- making the most of technologies: simple aspects of driver efficiency (for example, keeping tyres pumped up, controlling acceleration and not carrying unnecessary weight) can reduce fuel consumption by up to 15 per cent.

28. These choices would not only be positive for the environment, but would also benefit the individual by reducing the amount spent on fuel. However, there remain significant barriers to realising this potential. There is a gap between people's attitudes towards the environment and their actions through their choice of vehicle and the way they drive. Consumers discount heavily[5] fuel efficiency savings, so future savings from choosing a more efficient vehicle are not fully reflected in purchase decisions.

29. Part II makes a number of recommendations to address the barriers described above under three broad categories:

- choosing more efficient vehicles: ensuring clear and easy to understand information on CO_2 emissions and fuel economy is available, and strong incentives are in place, to enable and encourage people to choose the lowest emission vehicle that meets their needs;

[5] A high discount rate means that consumers are relatively unwilling to face a greater cost upfront in order to realise future savings, even if this would benefit them financially in the longer term. High discount rates can reflect a number of factors, including a lack of information on the value of any future savings, people valuing money today relatively highly against money in the future, and limited access to, or a high cost of, credit.

- driving more efficiently: using public information, training and dashboard technology to encourage drivers to adopt more efficient driving techniques, which reduce emissions and save drivers money through lower fuel costs; and
- using lower-carbon alternatives to the car: promoting public transport, walking and cycling, through increasing their availability and attractiveness and improving information, and encouraging people to make efficient use of cars – for example through car sharing and cars clubs – for journeys where this is the best option.

30. Recommendations 15 to 28 in Chapter 4 address these challenges.

Research and development challenges

31. In the long term, carbon-free road transport fuel is the only way to achieve an 80-90 per cent reduction in emissions, essentially decarbonisation. Given biofuels supply constraints, this will require a form of electric vehicle, with novel batteries, charged by "zero-carbon" electricity, or possibly hydrogen produced from zero-carbon electricity. Novel biofuels will also be an important part of the broader transport picture. Significant long-term scientific developments will be needed in all three areas – batteries, clean hydrogen and new biofuels.

32. For both batteries and hydrogen, clean cars will be dependent on clean power. Road transport CO_2 emissions will increasingly be determined by the power generating mix. Major changes in power generation therefore need to be delivered alongside new automotive technologies. Making progress on decarbonising power generation represents an even more urgent challenge than electric vehicle technologies because of the time it takes to implement.

33. Long term, with the right approach now, the UK could play a strong role in future electric systems and novel battery and energy storage solutions and in other areas such as biofuels development, building on current strengths in engine manufacture, high-tech vehicle and systems design and consultancy, and plant biology and breeding.

34. Part II sets out the key priorities for policy interventions in this area:

- an increased focus of UK public funding for R&D in this area;
- ensuring sufficient focus in the research community on the long-term scientific challenges and turning progress in these critical areas into an exciting "race";
- ensuring the R&D environment supports innovation at all stages in the chain; and
- influencing and collaborating with others to help achieve CO_2 reductions across the world, and in particular in the emerging economies where car ownership is increasing rapidly.

35. Recommendations 29 to 38 in Chapter 5 address these challenges.

A role for everyone

36. In achieving CO_2 reductions across all areas, everyone has a part to play: consumers, fuel companies, vehicle manufacturers, the power generation sector, the agricultural sector, businesses and government.

37. The overall challenge will require progress at a global level: the UK is responsible for only 3 per cent of global road transport CO_2 emissions, and fuel and vehicle manufacturers make decisions for a global market. Achieving international consensus and cooperation is essential in many areas. The UK can and should lead by example, demonstrating through sound policies that economic prosperity and carbon responsibility can be mutually supportive. The UK should also take a lead in discussions at the European and international level.

38. A full list of the recommendations made in this Review is set out below.

Full list of recommendations in this Review

Reducing vehicle emissions

Recommendation 1: The Review welcomes the EU's proposed regulatory approach for vehicles. It also welcomes efforts to demand consistent emissions standards and set a level playing field and supports the target date of 2012, which is challenging but technically feasible. The Review recommends that the EU agrees the detail at an early stage in order to give industry certainty and ensure the benefits of reductions in new car emissions are secured as early as possible.

Recommendation 2: The Review agrees that the EU should implement the 130g/km target based on the sales weighted average emissions of new cars sold in the EU. The Review also agrees with the EU proposals for setting individual manufacturer targets and supports the EU's plans to monitor the weight of vehicles in the run up to, and following implementation of, the legislation, to ensure that it does not provide manufacturers with perverse incentives to increase vehicle weight.

Recommendation 3: The EU should adopt a 100g/km new car sales weighted average target for 2020.

Recommendation 4: The EU should set in place a process for regular target setting every 7-10 years (or in line with future model cycles) to ensure that the industry can invest in and bring CO_2 saving technologies to market with certainty about the standards that the EU will require.

Recommendation 5: The Department for Transport, working with the European Commission, should work to design a CO_2 target for vehicles that captures the full CO_2 impact of vehicle production, disposal, usage and the production of the fuel or power used by the car.

Cleaner fuels

Recommendation 6: The Department for Transport should assess the case for a mandate to reduce the carbon intensity of the fuel mix covering all fuels, through a Low Carbon Transport Fuel Obligation, alongside other options to link the Renewable Transport Fuels Obligation to life-cycle CO_2 emissions already under consideration. The obligation should be enforced through a system of tradable credits.

Recommendation 7: The European Commission should develop policy instruments to provide flexibility between fuel and vehicle targets, such as allowing trade of credits between targets. In the absence of flexibility between targets, EU mandates on fuels and vehicles should be balanced such that the overall costs of reducing CO_2 emissions are minimised – at present, this suggests vehicle targets should be more stringent relative to fuel targets.

Recommendation 8: The UK Government should assess the case for inclusion of road transport in trading schemes such as the EU Emissions Trading Scheme (with fuels suppliers as the regulated entity).

Recommendation 9: To reduce the risk of damaging land-use change from large increases in biofuels production, the EU Fuel Quality Directive target on CO_2 (requiring a 10 per cent reduction in the carbon intensity of fuels by 2020) should be revised downwards and a gentler compliance trajectory be implemented.

Recommendation 10: The Department for Transport should lead on developing an agreed EU methodology for measuring the land efficiency of a biofuel, and consider how this might be reflected in policy options within the Renewable Transport Fuel Obligation and EU targets.

Full list of recommendations in this Review *(continued)*

Recommendation 11: Policies to prevent environmentally damaging land-use change around the world should continue to be developed as a matter of urgency alongside specific measures to reduce the land-use impacts of biofuels. The Department for Environment, Food and Rural Affairs should continue to make this a priority in international negotiations such as in the United Nations Framework Convention on Climate Change (UNFCCC).

Recommendation 12: Establishing a global market for biofuels is very important in ensuring fuels are decarbonised effectively and efficiently. This Review recommends that the UK Government continue to work internationally on developing a sustainable global market for biofuels. In particular by:

- encouraging convergence of global policies on fuels;
- working towards an internationally agreed carbon and sustainability reporting methodology; and
- reducing barriers to trade in biofuels.

Recommendation 13: The European Commission should conduct a study to assess the cost-effectiveness of different measures to enable blends of biofuels of 10 per cent or greater by energy content – reporting before 2010 – and use this to inform any future decisions on vehicle and fuel specifications.

Recommendation 14: Options to facilitate the efficient use of electric vehicles (such as smart-metering, time-of-day pricing, and fast charging points) should be considered alongside existing work by the Department for Business, Enterprise and Regulatory Reform (BERR) on smart-metering in the home and the Government's eco-towns initiative. In addition, BERR, the Department for Transport, and the power industry should include the impact of electric vehicles on the electricity grid in relevant scenario planning.

Consumer choices

Recommendation 15: Government should strengthen demand side policy measures to enable and encourage consumers to choose best in class or downsize. A package of measures is required to deliver change. Consumers should be provided with clear and easy to understand information on the running costs and emissions of different vehicles to support their purchase decisions. This must be backed up by strong and consistent price signals from Government to encourage people to choose the vehicle with the lowest CO_2 emissions that will meet their needs.

Recommendation 16: The Review welcomes the introduction of the fuel economy labels to inform consumer purchase decisions. To increase their impact the Department for Transport should:

- extend the labels beyond new cars to cover second-hand cars registered from March 2001 that are sold through dealerships;
- extend the labels to cover new and second-hand vans once the required information on CO_2 emissions is published for all new vans;
- make display of the labels compulsory on all vehicles in the range of the scheme; and
- include comparative information on CO_2 emissions and fuel economy on the label, through providing comparative figures on the class average or best in class vehicle, and by giving prominent information on the fuel cost savings that would result from choosing a more efficient vehicle, in addition to the absolute figures that are currently presented.

Full list of recommendations in this Review *(continued)*

Recommendation 17: Colour-coded tax discs should be introduced by the Driver and Vehicle Licensing Agency for cars registered from March 2001 that reflect the CO_2 emissions of the vehicle. The discs should be based on the vehicle excise duty bands, for example using a traffic light approach with different coloured discs for vehicles with lower, average and higher emissions.

Recommendation 18: Regulation of vehicle advertising should be strengthened so that information on CO_2 emissions and fuel economy is presented in a more prominent and consistent form in advertisements across all media. This should include a requirement to display comparative information on emissions relative to other vehicles in class. The Review recommends that the Department for Transport should establish an advisory group including the advertising industry and the Committee of Advertising Practice to gather and review available evidence and recommend the regulatory standards that consumers would find most helpful, reporting with specific proposals by the end of 2008.

Recommendation 19: The Department for Transport should develop and reinforce the "ACT ON CO_2" campaign. To enhance the effectiveness of the campaign:

- in addition to the current advertising campaign, the campaign's messages should be promoted to people face-to-face, for example through providing information in shopping centres, supermarkets and petrol stations. Drivers may be particularly receptive to messages on smarter driving when taking their vehicle for a service or MOT; and
- a greater focus should be placed on emphasising the financial benefits to consumers, as this is likely to influence the behaviour of a wider range of people.

Recommendation 20: The Department for Children, Schools and Families should ensure that children of all ages have the opportunity in school to learn how driving contributes to CO_2 emissions and how different choices can reduce its impact.

Recommendation 21: The Review welcomes local authorities introducing measures that incentivise consumers to choose lower emission vehicles where they are appropriately designed and are introduced with the objective of reducing CO_2. Where introduced, measures should:

- be based on carbon emissions rather than technology, equally incentivising all vehicles with equivalent CO_2 emissions;
- be maintained for a reasonable period of time to give consumers confidence in opting for lower emission vehicles. However, they should also be reviewed over time as the CO_2 emissions of the average car decline; and
- not encourage people to drive more, by making it easier or cheaper to do so, leading to increased congestion and higher CO_2 emissions.

Recommendation 22: All public bodies should look to match central government by setting an ambition to reduce the average emissions of new vehicles procured for administrative purposes to 130g/km by 2010-11.

Recommendation 23: The Department for Transport should promote the benefits of undertaking training in more efficient driving techniques, both to individuals and businesses, as part of the "ACT ON CO_2" campaign, and should provide accreditation to suitable training programmes.

Full list of recommendations in this Review *(continued)*

Recommendation 24: The Department for Transport should work with the European Commission and manufacturers to ensure an evidence base is developed on what dashboard technology could be safely incorporated into vehicles to promote more efficient driving. The European Commission should then regulate to make appropriate technology mandatory in all new vehicles sold in the EU. The Government should also promote and incentivise the retrofitting of technology to existing vehicles.

Recommendation 25: All local authorities should ensure that smarter choices are a priority in their local transport strategy.

Recommendation 26: The Department for Transport should work with local authorities to establish how a widespread implementation of personal travel planning could be sustainably funded. To strengthen the evidence base on the benefits of personal travel planning in different settings, the Department for Transport should consider establishing new pilots to assess the effectiveness of personal travel planning in larger urban areas.

Recommendation 27: All large public sector bodies should have a workplace travel plan in place by 2010.

Recommendation 28: Local authorities should consider promoting car clubs in their area as part of their local transport strategy. The Department for Transport should also raise awareness of car clubs so that people can make informed decisions over whether they are an appropriate option for them.

Research and development

Recommendation 29: The Review welcomes the Government's increased expenditure on R&D in recent years and recommends to Government and independent bodies responsible for public R&D funding that they increase the share of the funding assigned to low-carbon R&D, including low-carbon vehicles.

Recommendation 30: The UK organisations conducting and funding R&D should establish and publish clear statements setting out the distinctive roles that they will undertake, to provide clarity at the earliest opportunity.

In addition, the current arrangements as a whole should be evaluated by the Department for Innovation, Universities and Skills and HM Treasury in terms of effectiveness and value for money in advance of the next Government Spending Review.

Recommendation 31: The Technology Strategy Board and its partners should extend the Low Carbon Vehicles Innovation Platform to provide clear demonstration opportunities for new low-carbon vehicle technologies through implementation of experimental fleets linked to future procurement opportunities.

Recommendation 32: The Technology Strategy Board (TSB) should review the current support mechanisms for assisting companies in winning EU funds, and report by the end of 2008 on whether some of the other TSB "products", such as the Knowledge Transfer Networks, could play a stronger role in this area. The TSB should also work to strengthen UK influence within the Framework 7 transport programmes.

Recommendation 33: The Department for Environment, Food and Rural Affairs should facilitate an informed public debate, by exploring emerging evidence on the risks and benefits of genetically modified plants for non-food applications, in the context of the impact of climate change and wider sustainability issues.

Full list of recommendations in this Review *(continued)*

Recommendation 34: The new Research Centre on Sustainable Behaviours should make low-carbon cars an early priority, including the potential for future approaches to road charging, drawing on the Department for Transport's findings.

Recommendation 35: The Research Councils should urgently identify a limited number of critical long-term challenges and focus research efforts and funding around them, exploring innovative approaches to instil a sense of urgency and excitement for the research community and the wider public.

Recommendation 36: The UK Government should explore with other EU countries whether an EU level prize could be developed to find low-cost solutions for retrofitting to existing cars to reduce their emissions by a minimum of, say, 25 per cent.

Recommendation 37: The Research Councils and the Technology Strategy Board should examine whether it would be possible for their grant mechanisms to support innovative entries for major international prizes.

Recommendation 38: Government, industry and research bodies should look to forge links with counterparts around the world. More specifically, the Government should work with the Technology Strategy Board and other potential partners including the Research Councils, The British Council and UK Trade & Investment to design and fund a programme to support consortia of Indian and UK companies and universities to develop and demonstrate the "low-cost, low-emissions car".

Other recommendations

Recommendation 39: The Department for Transport should establish a clear implementation plan for leading progress across Government on the full range of recommendations.

This should be supported by a Steering Group made up of senior representatives of HM Treasury, the Department for Environment, Food and Rural Affairs, the Department for Business, Enterprise and Regulatory Reform and the Department for Innovation, Universities and Skills to provide cross Government support from the Departments that will need to take forward many of the recommendations.

Recommendation 40: The Sustainable Development Commission should be asked to report in 12 months time on the progress the Government has made in implementing the recommendations of this Review.

1 Context: the challenge for road transport

KEY MESSAGES FROM THE KING REVIEW PART I

1.1 The King Review Part I had a very positive message: that there is significant potential to reduce CO_2 emissions from cars, both in the next few years and in the medium and longer term. The UK is in a good position to take a leadership role in this area, bringing considerable benefits. However, this is a significant and serious challenge that we must address with urgency. Action is needed now by industry, consumers and government in order to achieve the emissions reductions required and to position the UK strongly for the new markets that will develop.

1.2 Road transport is fundamental to growth and mobility. In future, as the world continues to develop, road transport will continue to expand, bringing with it even greater benefits. We are already seeing rapidly growing demand for personal transport, in the form of cars, in developing economies such as China and India. Faced with the global challenge of climate change, it is essential to support this growing demand for road transport in a sustainable, environmentally responsible way. In doing this, significant opportunities for the UK economy can also be captured.

1.3 The Stern Review on the Economics of Climate Change set out the overall environmental challenge.[1] Stern concludes that the developed world, including the UK, needs to lead the way by achieving total emissions reductions of 60-80 per cent by 2050. Since the publication of the Stern Report in 2006, the advice from the scientific community is that the challenge for developing countries is becoming even greater. The UK has taken an important first step in introducing the Climate Change Bill, which commits the Government to reducing UK CO_2 emissions by at least 60 per cent by 2050.

1.4 The road transport sector must play its part in meeting this challenge. Transport accounts for 14 per cent of CO_2 emissions globally, and an even greater proportion in developed countries. Transport is responsible for 22 per cent of the UK's CO_2 emissions, with passenger cars contributing 13 per cent of the total. The UK and the rest of the developed world must lead by example, both by achieving substantial reductions in emissions and by coordinating and supporting international action.

1.5 The King Review Part I set out the contribution that cleaner fuels, more efficient vehicles and smarter consumer choices must make towards reducing CO_2 emissions:

- **short term** – over the next few years, significant CO_2 reductions could be achieved, at relatively low cost, in the main through the use of vehicle technologies that are already available and by realising the potential for smarter consumer choices. A 30 per cent improvement in new car efficiency is possible in the next 5-10 years, while smarter consumer choices could reduce emissions by 10-15 per cent;

[1] *Stern Review on the Economics of Climate Change*, 2006.

- **medium term** – by 2030, more efficient internal combustion engines, increased penetration of hybrids and the development of sustainable biofuels, alongside continued changes in consumer purchasing behaviour and driving efficiency, could reduce CO_2 per kilometre by 50 per cent (and total car CO_2 emissions taking into account increased demand, by about 30 per cent); and
- **long term** – in the longer term, possibly by 2050 in the developed world, almost complete decarbonisation of road transport is a realistic objective. This will require breakthroughs in electric battery and/or hydrogen technology and a "zero-carbon" source for charging or hydrogen production. This could reduce CO_2 per kilometre by 90 per cent (and total CO_2 emissions by 80 per cent).

1.6 Realising these savings is a significant challenge: urgent and sizeable. But it is achievable with strong action now. It will require major efforts from the automotive industry, the fuels sector and individuals. The move towards low-CO_2 fuels will require input from the power and agricultural sectors. There is also an important role for governments at all levels and in all countries who have the potential, through a wide range of policy levers, to address market failures and to influence the move to a prosperous, low-CO_2 economy.

TRANSPORT, GROWTH AND MOBILITY

Mobility is fundamental to economic growth and welfare

1.7 The Eddington Transport Study set out in detail the mechanisms by which transport feeds through to economic performance (Box 1.1 summarises the key points).[2] In future, as the world continues to develop, road transport use will undoubtedly expand, particularly in rapidly growing economies such as China and India, bringing with it even greater benefits.

Box 1.1: Key points from the Eddington Transport study

Transport is integral to economic performance, regionally and globally. It makes a significant contribution both to GDP and to welfare.

Transport needs to be an integral part of a pro-environment, pro-growth strategy.

Public transport provision and road pricing provide important ways of efficiently managing demand for transport.

Under a business-as-usual scenario, road transport in the UK is projected to rise by 28 per cent between 2003 and 2025.

1.8 For a century, the automotive industry has delivered technological advances that have contributed to economic growth and personal mobility. It has developed into a major, global industry. In 2006, over 60 million motor vehicles were produced and sold worldwide – 1.5 million, or 2.5 per cent, of these were manufactured in the UK. Annually, the UK automotive sector contributes £9 billion added value to the economy and employs 210,000 people.[3]

Carbon responsibility is now crucial

1.9 With the urgent challenge of climate change, it is now also necessary that carbon responsibility becomes a priority if the industry and, in the longer term, the global economy is to continue to prosper. The global challenge is to accommodate increases in road transport use, delivering greater mobility and economic growth, in a sustainable, environmentally responsible way. Just as technology has helped to achieve radical improvements in vehicle performance and safety since the beginning of the twentieth century, industry is now addressing its most important challenge to date: delivering environmental solutions.

[2] *Eddington Transport Study*, 2006.
[3] *A study of the UK automotive engine industry*, DTI, 2006.

THE CHALLENGE OF CLIMATE CHANGE

Climate change is a huge market failure

1.10 Climate change is a market failure on the greatest scale the world has seen.[4] The consequences of greenhouse gas emissions are felt by everyone, but with the strongest and most destructive impacts of climate change often not experienced by those who create the bulk of emissions. We cannot choose or control where the impacts of climate change occur. Climate change is global in its consequences, its impacts are long term and persistent, with a risk of major, irreversible changes, often occurring first in parts of the world least able to adapt. There is therefore a need for urgent, coordinated global solutions, as well as national efforts.

1.11 The Stern Review set out a compelling argument for urgent action against climate change (Box 1.2 outlines the key findings). Taking no action is the most expensive way forward. Stern estimates that, without action, the overall costs and risks of climate change will be equivalent to losing between 5 and 20 per cent of global GDP in perpetuity. In contrast, the overall costs of action can be limited to around 1 per cent of global GDP each year, provided action starts early. Because CO_2 is stable and builds up in the atmosphere over time, a tonne of CO_2 saved now is of greater value than a tonne of CO_2 saved later.

Box 1.2: Findings of the Stern Review

Climate change attributable to greenhouse gas emissions threatens the basic elements of life for people around the world:

- on current trends, global temperatures will be 2-3 degrees Celsius higher by 2050; and
- this is likely to lead to severe impacts including floods, droughts, population displacement, ecosystem destruction and malnutrition.

The benefits of strong, early action on climate change outweigh the costs.

To achieve CO_2 stabilisation below 550ppm, the world needs to reduce total emissions by at least 25 per cent by 2050. Ultimately, stabilisation will require global emissions cuts of 80 per cent relative to current levels.

Developed countries, including the UK, will need to contribute most, given economic and population growth elsewhere:

- Stern suggested that developed countries like the UK will need to achieve a 60-80 per cent reduction in total emissions by 2050.

The investment that takes place in the next 10-20 years will have a profound effect on the climate in the second half of this century and in the next century.

Policy to reduce climate change should be based on three elements: carbon pricing; technology policy; and removal of barriers to behavioural change.

The benefits of strong, early action on climate change outweigh the costs.

1.12 The UK is responsible for around 2 per cent of global CO_2 emissions but the Government has recognised the importance of leading by example. The Climate Change Bill that has been introduced to Parliament places a legal duty on the Government to reduce UK CO_2 emissions by at least 60 per cent by 2050. The UK will be the first country to put such a commitment into law.

[4] *Stern Review on the Economics of Climate Change*, 2006.

THE CHALLENGE FOR ROAD TRANSPORT

The global challenge

1.13 A challenge on the scale set out by Stern requires all sectors, including road transport, to make substantial progress in reducing CO_2 emissions. Globally, transport makes up 14 per cent of world CO_2 emissions.[5] Cars and vans contribute 45 per cent (and road transport as a whole 76 per cent[6]) of total transport emissions, the equivalent of 3Gt of CO_2 per year.[7]

1.14 However, as the Stern Review recognised, the transport sector, particularly on a global scale, is a challenging sector in which to achieve overall emissions reductions, because of the projected increases in demand. It is therefore particularly important that urgent progress is made in reducing emissions per kilometre.

Road transport use will increase

1.15 The process of globalisation and economic development in recent decades has been supported by a growing and innovative transport sector.[8] A similar story is anticipated in today's developing and emerging economies. China and India (with a total population of 2.5 billion, three times that of the EU and US combined[9]), are expected to double their share of world income in the next ten years[10] and rapid growth of road transport in those countries will play a key role in supporting that expansion. Car ownership in China has doubled in the last five years and it already has the third highest car sales in the world.

1.16 However, car ownership in China and India is currently a fraction of that in developed countries such as the US and UK. Over the coming decades, as these and other emerging economies grow, a very rapid rise in car ownership is projected.[11] In China, car ownership is projected to increase from 7 per 1,000 people in 2000 to 188 per 1,000 people by 2030, and 363 per 1,000 people by 2050.

1.17 The economic growth of China and India, along with continued growth in the world more generally, will compound the challenge of reducing CO_2 emissions from road transport. The World Resources Institute projects that, in the absence of mitigating policy, global CO_2 emissions from transport will almost treble by 2050. Consequently, to achieve Stern's environmental ambitions, whilst recognising the importance of road transport growth in increasing global mobility and economic output, it will be necessary to achieve very large reductions in average emissions (CO_2 per km travelled) by 2050, on the way towards almost complete decarbonisation of road transport.

The UK challenge

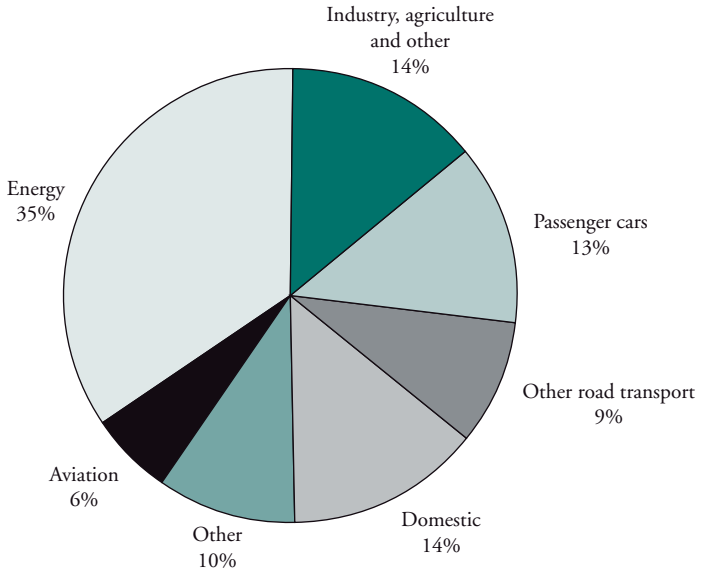
Emissions reductions of 80 per cent are possible

1.18 As in all sectors, the developed world needs to lead the way in reducing emissions from road transport. This Review's analysis indicates that, subject to progress in the power sector and in meeting a number of vehicle technology challenges, the UK, and the developed world more widely, could realistically aim towards reducing total road transport emissions by 80 per cent by 2050 (relative to 2000 levels).

[5] World Resources Institute, 2006.
[6] World Business Council for Sustainable Development, 2004.
[7] *Stern Review on the Economics of Climate Change*, 2006.
[8] *Eddington Transport Study*, 2006.
[9] *The World Factbook 2006-2007*, CIA.
[10] *Long-term opportunities and challenges for the UK: analysis for the 2007 CSR*, HM Treasury, 2006.
[11] *The BRICs and Global Markets: Crude, Cars and Capital*, Goldman Sachs, 2004.

1.19 In the UK, as in other developed countries, road transport emissions comprise a larger overall share of national CO_2 emissions relative to the global average. As Chart 1.1 shows, around 22 per cent of UK emissions are from road transport.

Chart 1.1: Sectoral contributions to UK CO_2 emissions in 2005



Source: AEA/DEFRA

Road transport use could double by 2050

1.20 An 80 per cent reduction in road transport emissions in the UK is a major challenge in itself, but this is made even greater by the fact that overall road transport use is projected to increase. The Eddington Review projects a 28 per cent increase in vehicle kilometres travelled between 2003 and 2025 under a business-as-usual scenario. Given continued economic growth, road transport use is likely to continue growing beyond 2025 and, based on current trends, could plausibly double by 2050.

1.21 This places even greater importance on improving the carbon-efficiency of road transport. If road use doubles by 2050, achieving an 80 per cent reduction in total road transport emissions would need the average level of CO_2 emitted per km travelled to be cut by 90 per cent. While this presents a significant challenge, this Review believes that it is achievable subject to substantial progress on a number of fronts, through cleaner fuels, more efficient vehicles, and better-informed and more environmentally friendly and economically aware consumer choices.

ROLE OF GOVERNMENT

Barriers to a market solution

1.22 As the Stern Review highlighted, climate change represents a huge market failure. The costs of greenhouse gas emissions are felt by all, not just by those who emit them, and will also be felt by future generations. People do not fully take into account these costs when choosing to generate emissions. Therefore, without leadership from government, businesses and consumers are likely to take insufficient responsibility for mitigating climate change, whether in road transport or in other sectors. In addition, there are a number of issues specific to road transport, which may delay progress or have important knock-on impacts. These are set out in Box 1.3.

Box 1.3: As well as climate change, there are a number of other potential market failures and knock-on impacts associated with reducing emissions from cars:

- barriers created by large fixed costs in fuel production and vehicle manufacturing, sunk costs and the efficient scale for bringing new technologies to market;
- gaps in understanding and information that may lead to sub-optimal behaviours. On the consumer side, this could include a lack of awareness of the potential financial benefits of low-carbon technologies, concern over early adoption of new technology or uncertainties about new vehicle models. For vehicle and fuel companies, it is likely to include the effect on decision making of uncertainty over future policy directions;
- the importance of the vehicle manufacturing and fuels sectors in contributing to economic growth and employment in the UK; and
- impacts on other policy objectives. For example, it is important to ensure that the path followed on fuel technologies aligns with Government's approach to wider energy policy, agriculture and global development.

Government has a role in enforcing accountability

1.23 Accountability is important at the international level, to ensure all countries take clear ownership of the challenge and the targets to tackle climate change – this is why there is an opportunity for the UK to play an important role in leading the way and coordinating activities in Europe and globally. In the past, progress has sometimes been hindered by a lack of accountability. For example, the voluntary agreement between European motor manufacturers to reduce new car emissions to 140g/km by 2008-09 is likely to fall far short of its ambitions. One reason for this is that the target has no proper enforcement mechanisms and the role of different agents is unclear – while it is recognised that government, vehicle manufacturers and the fuel industry all have a role, individual responsibilities have not been clear.

1.24 Government therefore needs to ensure that accountability for achieving emissions reductions is clearly set out. This is why Europe is moving towards clear requirements on fuel companies through the Fuel Quality Directive and Emissions Trading Scheme, and why a much more robust set of emissions targets is being proposed by the European Commission for vehicle manufacturers. In addition, consumers have a responsibility to play their part by maximising the potential of what is available – choosing the right vehicles and using them wisely. Government (at both a national and local level) must take the lead in making sure this happens – by ensuring consumers have clear and easily understandable information, and providing strong incentives for making choices that benefit both consumers themselves and the environment.

A package of policies is required

1.25 As well as ensuring that everyone has a clear role to play, government has the means, through its policies, to facilitate these roles and ensure that efficient markets are in place to realise the maximum potential. Government has a wide range of policy levers at its disposal including:

- fiscal policy;
- regulation;
- information provision;
- public procurement;
- R&D funding and incentives;
- negotiating and influencing;
- public transport and infrastructure policy; and
- wider central and local government policy.

1.26 Different levers are suited to different circumstances and a package of measures is required in order to achieve, in the most cost-effective way, the scale of CO_2 reduction that is both possible and necessary.

Demand and supply side measures are needed

1.27 Action is needed on both the demand and the supply side. Technology will have a major part to play, and vehicle and fuel manufacturers can make significant progress over the next few years. But there is a great deal of potential for savings from consumer choices, particularly in the short term, with scope for substantial benefits from realising "quick wins". This is true in the UK and even more so in some other parts of the world, notably the US where the average new vehicle emits about 60 per cent more CO_2 per km than the average new vehicle in Europe.[12] The UK can and should lead by example, demonstrating through sound policies that economic prosperity and carbon responsibility can be mutually supportive, and taking a lead in discussions at the European and international levels.

SCOPE OF THIS REVIEW

1.28 This Review focuses predominantly on cars (and small vans, which share common technology). Globally, these account for 70 per cent of road transport CO_2 emissions. Although the scope of this Review has been restricted to cars and vans, it is also important that progress is made in respect of trucks, buses and other vehicles, where there is also significant potential for reducing CO_2 emissions.[13]

The Review looks beyond the UK

1.29 The Review looks primarily at the UK context, recognising that developed countries like the UK must lead the way in reducing CO_2 emissions and in demonstrating that carbon responsibility and economic prosperity can be mutually supportive. However, the UK accounts for just 3 per cent of global CO_2 emissions from transport. Early, local action is not sufficient unless combined with the leadership that ensures others act too, particularly as many of the technological solutions are only properly viable on a European or larger international scale. The Review looks at the global challenge and stresses the importance of finding solutions that will work not only at the domestic level, but also in other European and global markets, including China, India and other rapidly emerging economies.

The Review looks beyond a 25-year horizon

1.30 This Review was set up to examine the technologies that could contribute to decarbonising road transport over the next 25 years. While complete decarbonisation of road transport is not likely within this time period, Part I set out a realistic ambition for 2030 that would constitute good progress for the UK in the context of a longer-term goal of effectively decarbonising cars. Part II sets out a policy framework for realising that potential.

1.31 This Review focuses on the challenge of reducing CO_2 (and other greenhouse gases, as explained in Box 1.4, below) emissions, which is necessary to combat the global challenge of climate change. However, its analysis and policy recommendations are underpinned by recognition of the need to achieve this in a manner consistent with other policy priorities – the wider environmental impact, mobility and growth, UK business interests, people's preferences, energy security requirements, cost-effectiveness, and other sectoral objectives and international development goals.

[12] Based on figures from *Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update*, ICCT, 2007.

[13] For example, see *Transport and Climate Change*, Commission for Integrated Transport, 2007.

Box 1.4: The focus on CO_2 emissions

CO_2 and other greenhouse gases

CO_2 is one of a number of greenhouse gases (the contributors to climate change) associated with road transport. For example, nitrogen oxides (NO_X), which are released from car exhaust pipes, soil conversion and use of fertiliser, are around 300 times as potent as CO_2 in terms of their impact as greenhouse gases. Methane is 21 times as potent as CO_2.

For the purpose of this Review, unless stated otherwise, CO_2 is used as a generic term for all greenhouse gas emissions – it is based on a "CO_2 equivalent" measure, with weights applied to reflect the potency of other greenhouse gases.

Air quality

A number of the harmful emissions associated with road transport, including hydrocarbons, NO_X and carbon monoxide, are detrimental to local air quality. This cannot be ignored, and in some cases there can be trade-offs:

- standard diesel currently results in lower CO_2 emissions but higher NO_X emissions than gasoline, although still delivering lower equivalent CO_2; and
- ethanol is generally a cleaner-burning fuel than gasoline, producing less CO_2, but results in higher concentrations of sulphur dioxide and other local pollutants.

However, in many cases, CO_2 and other harmful emissions will tend to decline together as we move towards cleaner fuels and more efficient vehicle technologies and driving. Even where trade-offs occur, because of the much larger amounts of CO_2 generated in combustion of carbon-based fuels, the CO_2 impact will normally be dominant.

STRUCTURE OF THIS DOCUMENT

1.32 This report sets out a package of policy recommendations to realise the potential for CO_2 reduction described in the King Review Part I covering four areas:

- reducing vehicle emissions (Chapter 2);
- cleaner fuels (Chapter 3);
- consumer choices (Chapter 4); and
- research and development challenges (Chapter 5).

1.33 Finally, Chapter 6 considers how these policy recommendations should be taken forward and recommends that the Sustainable Development Commission should be asked to report on the progress that has been made in 12 months time.

2 Reducing vehicle emissions

INTRODUCTION

2.1 Decarbonisation of road transport will require both cleaner fuels and new vehicle technologies, as well as action from consumers.

Vehicle technology could deliver 30 per cent CO_2 reductions in the next 5-10 years

2.2 The balance between vehicle and fuel technologies as the route to deliver the next step in CO_2 reduction in the most cost effective way will change over time. However, overall, the Review's analysis suggests that there is greater potential for cost effective reduction in CO_2 emissions over the next five to ten years through improvements in vehicle technologies. This is because the vehicle technologies needed to reduce CO_2 emissions by 30 per cent are already close to market, and in many cases are already available. These technologies could add to the cost of purchasing a vehicle, but this would be more than offset by reduced fuel costs through the vehicle life. The policy challenge is to ensure that vehicles with these technologies are brought to market as quickly as possible. Chapter 4 makes recommendations on stimulating demand: ensuring that consumers are encouraged to make low-carbon choices, creating a market demand for the lowest carbon technologies. This chapter considers measures to drive supply: ensuring car manufacturers bring low-CO_2 emissions cars to market.

50 per cent reductions in CO_2 are possible by 2030

2.3 Over coming years these technological advances can be expected to continue, with an increase in the use of hybrid technology and electric propulsion systems in cars. Through such advances, cars that emit 50 per cent less than today's models could be available by 2030. This would represent a clear step change in the technology used in cars.

2.4 Beyond 2030 it is less certain which technologies will dominate in low emissions vehicles, but almost complete decarbonisation will demand significant advances in technology. The main research and development challenges are discussed in Chapter 5. However, in tackling climate change, CO_2 abated now is worth more than the same savings later. Therefore, the short- and medium-term vehicle technology developments, as set out in the King Review Part I, will have a key role to play in securing large and early CO_2 emissions reductions on the long-term path towards completely "decarbonised" cars.

UK, EU and international intervention

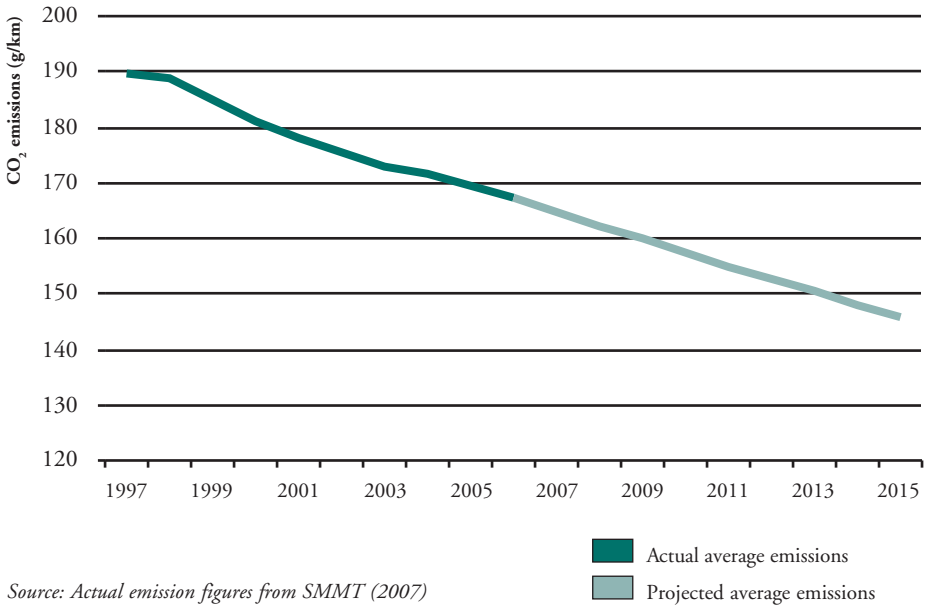
2.5 CO_2 emissions from cars are a global problem, and car manufacturers plan most of their new models to meet the requirements of multiple markets, so the consistency of demands from governments and consumers in different countries is important. This chapter discusses how, in the short and medium term, government intervention at the UK, EU and international levels can ensure that technology which leads to lower CO_2 emissions is made widely available in cars.

KEY POLICY CHALLENGES

CO_2 from new cars is falling but faster progress is needed

2.6 As the King Review Part I noted, average CO_2 emissions from new cars have been declining for a number of years, both in the UK and EU. Fuel consumption (and therefore emissions) are measured for each model of new car sold in the EU. As Chart 2.1 shows, new car tailpipe CO_2 per km in the UK fell at an average rate of 1.4 per cent per year between 1997 and 2006. Car manufacturers have gradually brought models with improved fuel economy to market.

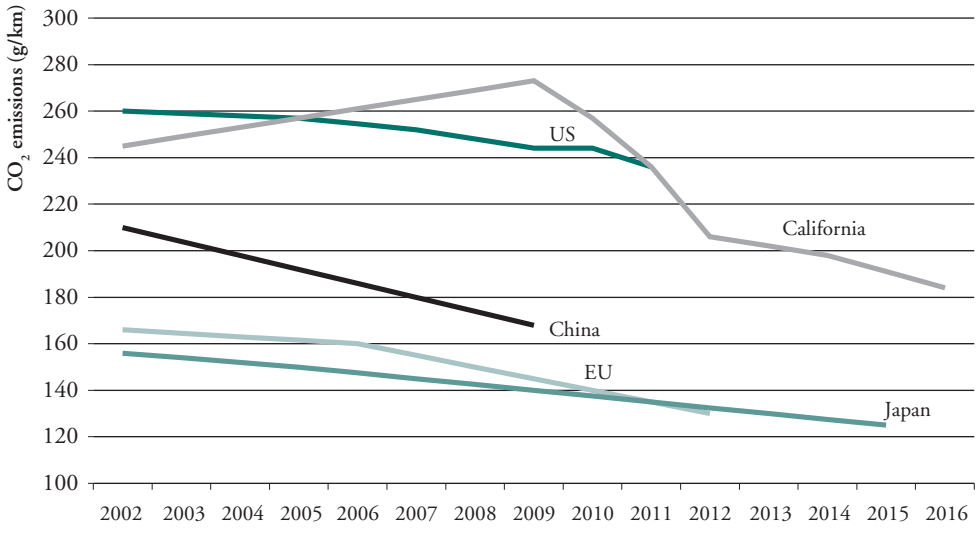
Chart 2.1: Actual and projected average new car tailpipe CO_2 emissions in the UK



Source: Actual emission figures from SMMT (2007)

2.7 Although CO_2 emissions have been falling and car efficiency has improved in Europe and Japan, in other large car markets average car fuel efficiency is much worse. Therefore, as Chart 2.2 shows, CO_2 emissions per car are considerably higher.

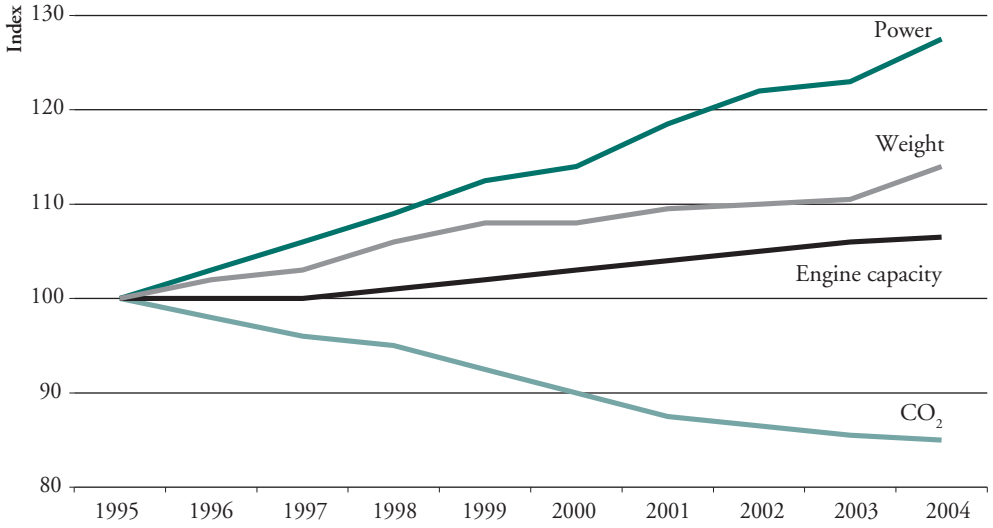
Chart 2.2: Actual and projected average CO_2 emissions for new passenger vehicles by country (2002-2016)



Source: The International Council on Clean Transportation (2007)

2.8 Recent improvements in engine technology, such as direct fuel injection, have helped to achieve increased fuel economy and reductions in CO_2 without sacrificing performance, cost or convenience to the car buyer. However, some recent trends and requirements in vehicle design have worked against CO_2 emissions reduction. Additional weight and less efficient aerodynamics, arising for example from requirements for improved safety and to reduce NO_x emissions, have offset some of the increase in vehicle efficiency that could otherwise have been achieved. Chart 2.3 shows how the weight, power and engine capacity of cars has increased between 1995 and 2004.

Chart 2.3: Changes in average vehicle CO_2 emissions, power, engine capacity and weight (1995 to 2004, indexed to 100 in 1995)



Source: ACEA

2.9 CO_2 from new cars would be reduced significantly if technology already "on the shelf" were deployed in cars in the showroom. Table 2.1 shows how incremental technologies could reduce average new car CO_2 emissions by up to 30 per cent. However, trends towards an increase in engine size, power and additional electrical equipment will need to slow if the maximum potential for CO_2 reductions is to be realised.

Table 2.1: Technologies that could increase car efficiency and indicative additional production costs

Technology	Efficiency saving	Cost per vehicle (£)
Direct injection and lean burn	10–13%	200
Variable valve actuation	5–7%	175
Downsizing engine capacity with turbocharging or supercharging	10–15%	235
Stop-start	3–10%	Less than 500
Reduced mechanical friction components	3–5%	–
Light weighting	10%	250–500
Low rolling resistance tyres	2–4%	50–100
Improved aerodynamics	2–4%	–

Ranges derived from a number of sources, including the International Energy Agency (IEA), Institute of European Environmental Policy (IEEP), California Air Resources Board (CARB), and Ricardo. Cost estimates were derived using approximate conversion to Sterling.

Note: both costs and efficiency savings are not necessarily additive.

2.10 The technology that could reduce emissions by 30 per cent could be cost effective for an individual consumer. For example, depending on the type of car and the technologies used, it could cost around £1,000 to £1,500 per car to reduce CO_2 emissions by 30 per cent through new technologies.[1] This level of cost increase would be offset by fuel savings over the life of the average car. For example, a 30 per cent efficiency saving would reduce the fuel costs per mile of a small family car by around 4 pence per mile,[2] and that would mean that the additional purchase cost would be repaid in 25,000 to 37,500 miles or a 2-3 year period of ownership for a consumer who drives 12,000 miles a year. However, in a highly price sensitive market for vehicles, where consumers discount heavily future savings from fuel efficiency, this level of additional upfront cost may be enough to deter car buyers – and therefore manufacturers – from making this technology standard across model ranges.

The challenge of adopting new technologies

2.11 Evidence suggests that while consumers list fuel consumption and running costs as important factors in choosing a car,[3] most consumers do not fully value future fuel savings at the time of vehicle purchase.[4] Environmental concerns and vehicle emissions do not tend to feature highly in the factors people consider when choosing which car to buy, with performance, power, engine size and brand image rated as more important.

[1] In some cases emissions could be improved by actually removing technology from cars, e.g. some of the electronics.

[2] Cost of petrol = 474.2p/gallon (*Fuel Price Report January 2008*, AA, 2008).

[3] *Car buyer research report*, Low CVP, 2005.

[4] *Testimony to the Senate Commerce Committee: Oversight Hearing on the Corporate Average Fuel Economy Program*, Dr. David L Greene, March 2007.

2.12 In many cases it is less costly for car manufacturers to add performance incrementally. Whereas car buyers are willing to pay more for this additional performance, most private buyers are reluctant to pay a large premium for greater economy. Early models that adopted stop:start technology and lightweighting were not commercially successful. Manufacturers have often sunk considerable investment into current technologies and, at a time of low margins, may be reluctant to invest in bringing new technologies to market, especially where demand appears slow to develop. For instance the Toyota hybrid vehicle technology has taken ten years to achieve annual worldwide sales of 600,000 vehicles.

Multinational car markets require international cooperation

2.13 Vehicle manufacturing is a global business, and new products are usually planned for the European, American or Asian markets, or all three. Policy targeting the level of CO_2 emitted from cars sold in the UK alone would be an expensive option for the industry and would have limited impact on CO_2 emissions compared with wider ranging policy. Action must therefore be taken at a European (or international) level as well as through domestic UK policy.

2.14 This chapter addresses how international supply side policies can be used to reduce average new car CO_2 on a cost effective basis. Chapter 4 on Consumer Choices considers demand side policies at the UK level which will also be required in order to reduce average emissions.

CURRENT POLICY CONTEXT

Achievement against the EU voluntary agreement has fallen short of its ambitions

2.15 The main existing vehicle related policy aiming to reduce the CO_2 emissions of new cars sold in the EU is the voluntary agreement that the European Car Manufacturers' Association (ACEA) entered into in 1998, and the Japanese and Korean manufacturers' associations (JAMA and KAMA) adopted in 1999. ACEA signed up to reduce average new car CO_2 emissions in Europe to 140g/km by 2008, and JAMA and KAMA by 2009. As average emissions are currently 160g/km, and have reduced at around 1.4 per year, the trajectory suggests that manufacturers will miss the target by some margin (Chart 2.1 shows the UK trend).

2.16 There are a number of reasons why achievement against the target has fallen short of its ambitions. The voluntary agreement lacks a mechanism for assigning targets to each manufacturer, so there has been insufficient accountability on individual players within the industry to meet the target. There are also insufficient sanctions on the industry or individual manufacturers for failing to meet the commitment. To overcome these drawbacks, the European Commission has proposed legislation that would bind vehicle manufacturers selling cars in Europe to reduce the CO_2 emissions of the new cars they sell. Regulation is likely to be an effective tool in this area because it brings greater certainty about the overall standard that will be reached and provides a level playing field for the industry.

Proposed EU regulation

2.17 In December 2007 the European Commission issued proposals to regulate for a 130g/km tailpipe emissions target to be reached on a European sales weighted average basis[5] by 2012 (see Box 2.1). Under the proposals every volume manufacturer would be assigned a mandatory target based on the vehicle weight of the average car they currently sell. Vehicle manufacturers that miss the target would be fined. The fine for each g/km by which the manufacturer's average car misses the target would increase sharply from €20 per g/km per car sold in 2012, €35 in 2013, €60 in

[5] Henceforth all references to the "average car sold" refer to the sales weighted average.

2014, through to €95 per g/km per car sold in 2015 (e.g. under the proposed regulation if the manufacturer misses the target by 5g/km in 2012, the fine will be 5 multiplied by €20 multiplied by the total number of cars they sell in the EU). De-minimis manufacturers selling less than 10,000 vehicles per year would be able to apply for an alternative target. Manufacturers may form a pool for the purposes of determining compliance with the targets.

Box 2.1: Sales weighted averages

The sales weighted average emissions of a manufacturer takes into account how many cars at each emission level a manufacturer actually sells, not just the average emissions of the models in the range. For example a car manufacturer sells:

10,000 x small cars (that emit 140g/km of CO_2);

20,000 x medium sized cars (that emit 160g/km of CO_2); and

15,000 x large cars (that emit 190g/km of CO_2).

When the number of each cars sold is taken into account, then the sales weighted average emissions of that manufacturer are: (10,000 x 140) + (20,000 x 160) + (15,000 x 190) divided by the total number of cars that the manufacturer sells (45,000) giving a sales weighted average of 166g/km to the nearest gramme. If the manufacturer sold 10,000 more small cars and 10,000 fewer large cars, their sales weighted average would fall to 154g/km.

Measuring the average in this way means that manufacturers cannot meet the proposed EU legislation simply by producing a very low CO_2 model and selling it in very small numbers.

2.18 The 130g/km tailpipe emissions target would form part of an integrated approach, and would be complemented by measures to deliver a carbon saving equivalent to a further 10g/km to meet the Commission's stated objective that the new car fleet reaches an average of 120g/km by 2012. The additional 10g/km would be deemed to be achieved through other technological improvements, such as fitting gear shift indicators and tyre pressure monitoring systems and the use of low resistance tyres, as well as an increase in the use of biofuels.

UK policy

2.19 To date the UK has focused on ensuring that consumer demand supports the shift towards low-carbon cars. Fiscal measures, including differentiated vehicle excise duty (VED) and company car tax (CCT) based on CO_2 emissions, have been introduced to incentivise lower emission vehicles. The motor industry has rolled out a voluntary labelling scheme for new cars displaying fuel efficiency and CO_2 information, while the "ACT ON CO_2" campaign has been launched by Government to promote the benefits of choosing more efficient vehicles. Chapter 4 discusses these existing interventions and makes recommendations for further action. The remainder of this chapter makes recommendations for supply side measures to encourage vehicle manufacturers to maximise CO_2 reductions in their fleet.

International efforts

2.20 Other countries are also addressing fuel efficiency and climate change through regulation. Nine government bodies around the world – including the European Union, United States, California, China, South Korea and Taiwan – have proposed, put in place or are revising car (and in some cases light duty van) fuel economy or CO_2 emission standards. Of the 30 OECD nations only five – Iceland, Mexico, Norway, Switzerland and Turkey – do not currently have programmes to reduce car CO_2 emissions or fossil fuel use.

Japan

2.21 Japan already has legislation in place which, alongside Europe's, is the most stringent in the world – it is expected to lead to fleet CO_2 emissions of 125g/km by 2015. Japan's approach to regulation sets car fuel efficiency targets for 16 weight categories of vehicle based on the "top-runner" or most efficient vehicle in each class in the base year. Each vehicle category target is set by starting with the fuel efficiency of the "top-runner", and adjusting it for factors that can be foreseen such as technical improvements that would improve efficiency, and negative factors that would have an adverse impact such as regulatory requirements to reduce other pollutant emissions and improve crash protection. This then becomes the standard for the target year. Hybrid vehicles are excluded from this approach. Japan's system of regulatory standards is also supported by a fiscal regime that provides incentives to buy lighter vehicles with smaller engines.

China

2.22 China is a relatively new entrant to the field of regulating fuel economy. The country's new passenger vehicle market has been subject to fuel economy standards since 2005. The regulations are designed to reduce dependence on foreign oil and encourage foreign car makers to bring more fuel-efficient vehicles to the Chinese market. The fuel economy standards set fuel consumption upper limits for each weight category of vehicle. This will therefore effectively set CO_2 emissions limits for each type of vehicle. China is also tackling this issue through demand side measures, including reform to vehicle excise duty and the removal of a preferential tax rate that applied to SUVs. Increasing car ownership in emerging markets, and the tendency for the lifecycle of a car to be longer than in Europe, mean that it is important that affordable ways of improving the fuel efficiency of both new and existing cars are urgently found and implemented.

North America

2.23 North America is the world's largest car market. However the cars sold there are some of the least fuel efficient in the world. The North American market tends to demand larger and (on a like-for-like basis) cheaper cars than Europe and Japan. Fuel in North America is significantly cheaper than in Europe, mainly due to lower rates of tax on fuels. The market therefore tends to favour cheaper and less efficient engine technologies than other markets, including Europe. The US adopted Corporate Average Fuel Economy (CAFE) standards as part of a broad energy security policy package during the 1973 oil shock. The Act required motor vehicle manufacturers to increase the sales weighted fuel economy of new passenger vehicles sold in the US from 13.6 miles per gallon (mpg) in 1974 to 18 mpg by 1978, and then to 27.5 mpg in 1985. Although brought into force in 1975, the CAFE standard for passenger cars has remained unaltered since 1985 at 27.5 mpg. This is approximately equivalent to CO_2 emissions of 235g/km from a petrol car.

2.24 The CAFE standard for light trucks – which encompasses minivans and SUVs – has increased in recent years in response to fuel efficiency declining by 7 per cent between 1988 and 2004, coupled with the market share of these vehicles becoming greater than that of cars. The CAFE standard will increase from 20.7 mpg in 2004 to 24 mpg in 2011. In the most recent round of regulation the National Highway Traffic and Safety Administration has allowed manufacturers to choose between targets based on either the new light truck average or size (vehicle footprint) between 2008 and 2010. From 2011, manufacturers will be required to meet size-based targets that are expected to result in a new light truck average of 24 mpg (equivalent to just under 260g/km). Compared with the improvement that Europe and Japan are demanding from vehicle manufacturers over the same period, the pace of CO_2 reduction is slow – at around 1 per cent per year – and starts from a much higher baseline.

2.25 The Californian state government has proposed more ambitious emissions standards than those put forward by the US Environmental Protection Agency (EPA). California has regulated to demand a 30 per cent reduction in new car average greenhouse gas emissions by 2016 relative to a 2009 baseline. As a result of the legislation total greenhouse gas emissions from the vehicle fleet are expected to stabilise until 2020 after increases in vehicle mileage are taken into account. Upstream emissions associated with the production of fuel used by the vehicle are to be taken into account in the Californian standards. Since their introduction, the Californian standards have been adopted by eleven other states in the US, and several Canadian states have shown an interest in following suit. In December 2007, the EPA denied California the right to set more stringent standards. If California and the other states that support it succeed in their legal challenge to set their own standards, these standards would seek to reduce greenhouse gas emissions from more than one in three new vehicles sold in the US.

2.26 Ultimately it would be helpful if there was a consistent but challenging global agreement on increasing vehicle efficiency and reducing emissions. However, it is unlikely that this could be achieved in the near future given the different starting points and challenges for different nations.

POLICY MEASURES

Regulation at EU level

2.27 This Review believes that the regulatory approach proposed by the EU, and similar regulatory regimes being designed or implemented in other countries, offers the best prospect for bringing lower CO_2 technology to the showroom more quickly. Regulating the industry will provide much needed certainty about the standards that will be required and create a level playing field for manufacturers in the European market. This section looks at how regulation at the EU level can reduce CO_2 across the range of cars that manufacturers produce on a cost-effective basis for the industry and the consumer.

2.28 Some vehicle manufacturers have indicated that they view the target of 130g/km in the proposed legislation as costly and technically difficult to achieve by 2012. Manufacturers plan new car models up to five years in advance of the launch date, so the models that will be released in 2012 are already in the early stages of development.

Regulation will bring certainty

2.29 This Review believes that the target is technically achievable without manufacturers reducing the size of the vehicles they offer in the most popular segments of the market – if they deploy existing carbon saving technologies at the earliest opportunity. Vehicle manufacturers have been aware of the EU's intention to introduce regulation with respect to vehicle CO_2 emissions since 1995 and have therefore already had more than a decade to develop the technologies that can reduce emissions. Regulating for 2012 would bring much needed certainty and reward manufacturers who have taken early action. The "green" models released by most of the major vehicle manufacturers show what is already achievable with relatively incremental modifications to existing models (see Table 2.2). The detail of the Commission's proposals also acknowledge and make provision for the fact that some manufacturers produce larger models of car.

Table 2.2: Examples of the lowest CO_2 emitting cars available now

Make/model	Size of car/engine type	CO_2 emissions (g/km)
VOLKSWAGEN POLO BLUEMOTION 1.4 TDI (WITHOUT AIRCONDITIONING)	Supermini/diesel	99
SEAT IBIZA 1.4 TDI	Supermini/diesel	99
PEUGEOT 107 1.0	Supermini/petrol	109
VAUXHALL ASTRA 1.4	Small family car/petrol	146
HONDA CIVIC 1.4 HYBRID	Small family car/hybrid	109
BMW 1-SERIES 118D 3 DOOR	Small family car/diesel	119
TOYOTA PRIUS 1.5	Large family car/hybrid	104
FORD FOCUS C-MAX TDCI	Mini-people carrier/diesel	124
FORD MONDEO 1.8 TDCI	Large family car/diesel	139
RENAULT LAGUNA HATCH DCI	Large family car/diesel	130

Source: dft.gov.uk/actonco2

Recommendation 1: The Review welcomes the EU's proposed regulatory approach for vehicles. It also welcomes efforts to demand consistent emissions standards and set a level playing field and supports the target date of 2012, which is challenging but technically feasible. The Review recommends that the EU agrees the detail at an early stage in order to give industry certainty and ensure the benefits of reductions in new car emissions are secured as early as possible.

Manufacturer accountability

2.30 Under the Commission's proposals, the 130g/km target would be translated into individual targets for each manufacturer to ensure accountability and clear responsibilities for meeting the target. Each manufacturer would be assigned a target level of CO_2 emissions per km based on the sales weighted average vehicle they sell. This sales weighted approach has been proposed by the EU in preference to setting limit values – emissions standards that no vehicle sold would be permitted to exceed, which could be set either as a single CO_2 emissions limit for all vehicles or different emissions limits for each vehicle category (e.g. small cars, medium cars).

2.31 The use of limit values would suffer from a number of drawbacks. Initially, an overall limit value would need to be set at a high level to provide a realistic target for the larger and less efficient models that already exist. However, few cars are sold at the very top of the range, and a target of this nature would provide little incentive to reduce the emissions of the other cars in the range, where many more cars are sold. A target based on vehicle categories may be more effective in this respect, but it could be difficult to categorise some models, and it could provide manufacturers with an incentive to push cars into the next class to get a less challenging target. It would also not provide manufacturers with any incentive to change the "mix" of vehicles they sell towards smaller cars in the range.

2.32 In contrast, a sales weighted average approach would allow greater flexibility to industry. It would enable manufacturers to improve efficiency where it is cheapest, and would therefore reduce emissions at lower cost than setting limit values. It would also offer the greatest incentives for each manufacturer to reduce the emissions across the range of vehicles that they offer. The Review therefore supports the use of a sales weighted approach.

2.33 The specific sales weighted emissions target each manufacturer would be responsible for could be set in three ways, the impacts of which are illustrated in Table 2.3:

- **fixed target** – set the same target for all manufacturers (e.g. 130g/km). The scenario shown in Table 2.3 sets targets equal to the overall fleet target (i.e. 130g/km) for all three manufacturers A, B and C. Manufacturer A has sales weighted average baseline emissions of 140g/km, manufacturer B 150g/km and manufacturer C 180g/km. Manufacturers B and C produce heavier cars than manufacturer A and so need to reduce the emissions of their vehicles by a greater amount to reach the target;
- **a percentage-based reduction** – each manufacturer has to achieve a specified percentage reduction in their emissions over their baseline level (2005), e.g. to reduce the fleet average from 162g/km to 130g/km would require a 20 per cent reduction from each manufacturer, this would mean manufacturer A would be given a target of 112g/km, manufacturer B 120g/km, and manufacturer C 144g/km. This would place a much larger burden than a fixed target on manufacturers who are already making cars that have low CO_2 emissions; or
- **utility-based target** – this would take into account the greater practicality of larger cars for certain users, and the fact that it can be more difficult to reduce the CO_2 emissions of a larger, heavier car to a certain level than for a smaller car. A utility-based target could in principle spread the cost of CO_2 reduction more evenly between the makers and customers of smaller and larger cars. This is the basis for the EU proposal.

Table 2.3: CO_2 reductions required under fixed and percentage-based targets

Manufacturer	Baseline emissions (2008)	Reduction required from a fixed target of 130g/km (g/km)	Reduction required by a 20 per cent target (g/km)
A	140	–10	–28
B	150	–20	–30
C	180	–50	–36

2.34 The Commission has favoured the third approach, proposing that each vehicle manufacturer should be set a different target based on the range of vehicles they sell. This would mean, for example, that a manufacturer who produces mainly large family cars would be set a higher emissions target than a manufacturer who produces mainly smaller cars. This would recognise that a family car is larger and therefore likely to be heavier and less efficient than, for example, a supermini, and would ensure that each manufacturer could continue to offer a range of cars according to customers' needs.

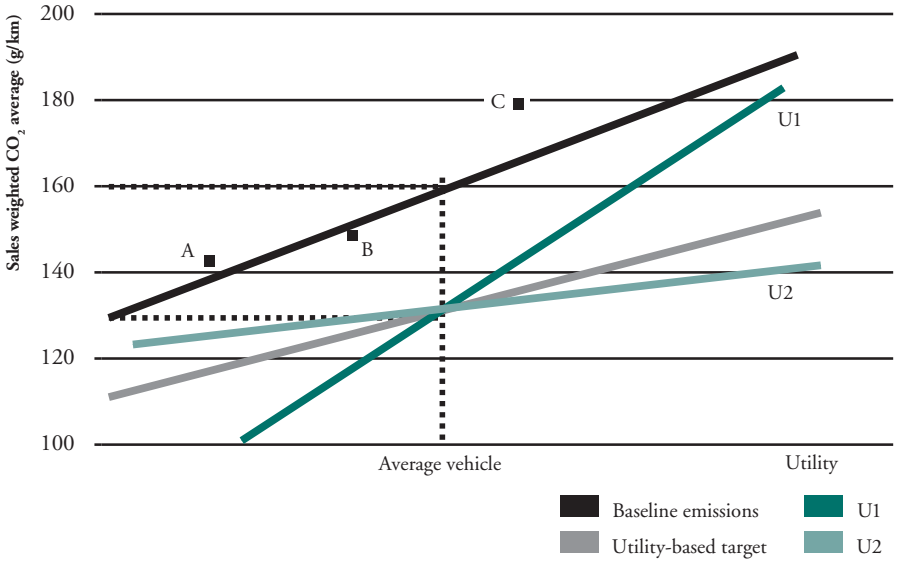
Box 2.2: Utility-based manufacturer emissions targets

The system for allocating emissions targets to individual manufacturers makes a difference to how cost-effective the regulation is and how the cost of the regulation is distributed within the industry.

Under current EU proposals, utility-based targets for each manufacturer would be set using a "utility curve". The utility curve represents the relationship between a proxy for practicality or size of a manufacturer's cars (such as weight or the area covered by the vehicle chassis) and the CO_2 target they would be assigned. The higher the utility of the car, the higher the target assigned to the manufacturer would be. The greater the amount the manufacturer's target is adjusted as the utility parameter is changed the steeper the utility curve would be.

The diagram below shows a plot of manufacturers' baseline emissions that are 160g/km for the average vehicle, and a utility curve plotted around the 130g/km industry target.

Diagram 2.1: The impact on manufacturer targets of the utility curve slope



The slope of the utility curve is important in terms of where the cost of regulation would fall within the industry. A very steep curve such as U1 would impose a tougher target and higher cost on the makers of smaller cars. Conversely a relatively flat line such as U2 would demand very high and costly levels of abatement from makers of mainly larger cars.

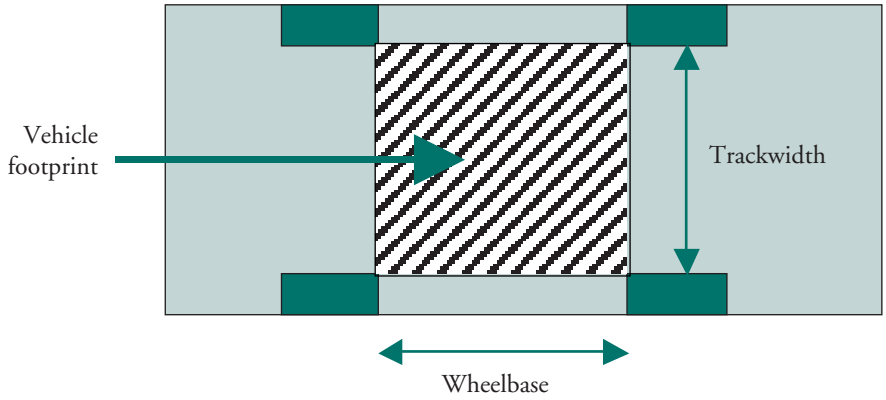
The parameter by which the utility-based target curve is set should not reward manufacturers that increase vehicle size or weight with a target that is easier to meet. The parameter used should therefore not be easy to manipulate. The slope of the utility curve is also important – a steep utility curve could give manufacturers an incentive to make larger cars, as they would have to reduce the emissions of their vehicles less than if they produced smaller cars.

2.35 The European Commission has proposed the sales weighted average vehicle weight within the target year should be the parameter by which manufacturers targets are set. Generally the larger a car is, the more it weighs. Creating variation among manufacturers' targets according to the average weight of the vehicles they sell – along a target curve – reduces the overall cost of a given industry-wide target to the industry as a whole. This is because it shares out the amount of abatement required from each manufacturer more evenly than a fixed target. However, a weight-based target reduces incentives for manufacturers to reduce the weight of their vehicles, and indeed

could encourage manufacturers to add weight to their vehicles to gain an easier target. This could result in each manufacturer meeting their own target, but the overall 130g/km target for the industry being missed. A target curve (see Box 2.2) that is relatively shallow reduces this risk.

2.36 An alternative parameter by which manufacturers' targets could be set is the vehicle footprint, as illustrated by Diagram 2.2.

Diagram 2.2: Vehicle footprint



2.37 Footprint would be harder for manufacturers to manipulate, as it would require a complete redesign of the base of the car. However, vehicle footprint data are not readily collected, so it would be difficult to bring in regulation based on this measure for 2012. The Review is therefore supportive of the proposal to base the regulation on weight, and agrees with the Commission's intention to monitor the weight of vehicles in the run up to, and following, implementation of the legislation, to ensure that manufacturers do not increase the weight of their vehicles in order to receive a less stringent target.

Recommendation 2: The Review agrees that the EU should implement the 130g/km target based on the sales weighted average emissions of new cars sold in the EU. The Review also agrees with the EU proposals for setting individual manufacturer targets and supports the EU's plans to monitor the weight of vehicles in the run up to, and following implementation of, the legislation, to ensure that it does not provide manufacturers with perverse incentives to increase vehicle weight.

Pooling

2.38 The Commission's recommendation for pooling offers manufacturers an opportunity to have any under-achievement against their target offset against over-achievement by another manufacturer. Manufacturers would need to enter a pooling agreement to enable this to happen. Those that surpass their target would almost certainly demand payment to pool with a manufacturer that is unlikely to meet their own target. Pooling could enable manufacturers that otherwise would find it expensive to abate the emissions of their vehicles sufficiently to strike a deal with manufacturers that are able to over-achieve against the target. The pooling agreements would have to be agreed in the absence of perfect information on both sides about the other manufacturers' ability to meet the target, and likely sales figures for each model. In practice there may be a limited number of manufacturers able to trade over-abatement against the target. This could make it harder for smaller firms to pool with other manufacturers and as a consequence this

could have wider implications for competition in the EU car market. This suggests that a more liquid trading scheme between vehicle manufacturers may be needed at some stage in the future. This could be more cost effective if it enables each gramme of over-achievement to be offset where it is most efficient. Meanwhile, if the proposed pooling arrangements form part of the final regulation, the European Commission should monitor how well the system works.

Ensuring compliance

2.39 The proposed legislation contains fine levels that would increase for each year a given amount by which the sales weighted average target for each manufacturer was missed. For the regulation to succeed in the overall aim of reducing the CO_2 emissions from the average car sold in Europe to 130g/km, it must be cheaper for the manufacturers as a group to abate the CO_2 emissions of the cars they sell than to pay the fine. The proposed fine levels in 2015 are higher than nearly all manufacturers' likely costs of abatement, suggesting that they would opt to comply with the regulation rather than pay the fine. However, manufacturers that are faced with very high abatement costs would have the option to pay the fine or to pool with another manufacturer.

The costs of regulation

Costs

2.40 Current indications suggest that the additional cost of meeting the EU's regulatory target would be in the range £450-£650 for the average vehicle.[6] If this were to be passed through to the purchase price, the consumer would be able to recoup the extra purchase cost within a typical ownership period through reduced fuel costs. Recently published Cambridge Econometrics research for the Department for Transport (DfT) suggests that consumers would be willing to pay an extra £510 for a car in return for reduced fuel costs of £1 per 100km.[7] Reducing emissions from 160g/km to 130g/km would save about £1.25 in fuel cost per 100km suggesting that the cost of reducing emissions would be in line with what consumers are willing to pay for the resulting gains in vehicle efficiency. This suggests that consumers are willing to pay fairly substantial amounts for efficiency improvements, but tend to discount heavily future fuel savings, and therefore the payback period would need to be fairly short.

Table 2.4: Payback period from petrol car efficiency improvements resulting from a reduction in emissions from 160g/km to 130g/km

Annual mileage (miles)	Payback period for average increased purchase price[8]
18,000	18 months
12,000	2 years 3 months
6,000	4 years 6 months

2.41 The cost to society of abating a tonne of CO_2 emitted was estimated in the analysis for the Energy White Paper[9] for the purpose of benchmarking the value of carbon emissions saved. These cost estimates show that reducing vehicle emissions by increasing fuel efficiency offers good value for money, and compares well in terms of cost effectiveness with measures to reduce carbon emissions from fuels, rather than vehicles, such as extension to the Renewable Transport Fuels Obligation (which is discussed along with other fuels policy in Chapter 3).

[6] *A Competitive Automotive Regulatory Framework for the 21st Century: Commission's Response to the CARS21 High Level Group Final Report – Impact Assessment Report*, European Commission, 2007.
[7] *Demand for Cars and their Attributes*, Cambridge Econometrics, 2008.
[8] Payback period based on a cost of petrol of 474.2p/gallon (AA, *January 2008 Fuel Price Report*) and additional purchase cost of £550.
[9] *Meeting the energy challenge: A White Paper on Energy*, Department of Trade and Industry, 2007.

2.42 As discussed above, the Commission's proposal would impose fines on vehicle manufacturers who missed the 2012 target. This would provide an incentive for manufacturers with low abatement costs to comply with the legislation earlier than manufacturers with higher short-term abatement costs, who have the flexibility to pay the fines. The fine levels increase to a level by 2015 where nearly all manufacturers would be likely to find it less costly to abate than pay the fine.

Box 2.3: Historically the motor industry has risen to the challenge

In the US, the drive for regulation of vehicle emissions began in the 1960s. Air quality and health concerns were the key determining factors in pushing forward regulation. The State of California enacted legislation via the California Air Resources Board (CARB) to tackle smog and other air pollutants, and standards were set at the federal level through the 1967 Air Quality Act by the Environmental Protection Agency (EPA) for emissions of carbon monoxide, nitrogen dioxide, ozone, sulphur dioxide and particulate matter (PM-10).

In 1970 the EPA prepared an amendment to the Clean Air Act (legislation passed in 1963 covering various forms of air pollution) which required a 90 per cent reduction in regulated vehicle emissions by 1975-76. Car manufacturers lobbied hard against this legislation, including testifying in Congressional hearings that such legislation would lead to high cost burdens which threatened the commercial viability of the US car manufacturing industry. Despite successfully challenging the amendment, car manufacturers recognised that public and political concerns on air quality were not going to fade, and indeed automakers were installing catalytic converters in over 80 per cent of vehicles by 1975.

During the 1990s, regulating for low emission vehicles remained a cause for debate. For example, in 1994, automobile manufacturers estimated that the cost of low emission vehicles would be in excess of $1,500 above the cost of comparable car models.[10] However, one year after this estimate, Honda placed a Civic subcompact model on the market that emitted less than half of what was permitted regulated emissions in 1995.[11] This vehicle cost only $100 more than comparable models. In, 1990 CARB estimated the average incremental cost of a low emissions vehicle to be $170. Industry estimates in California were $788. In 1998 it was found that the actual incremental cost of low emission vehicle technology was $83.[12]

The Californian and US authorities have continued to send long range signals to the market and this has driven significant incremental innovation in emission technology, resulting in significant improvements in exhaust emissions whilst the purchase price of vehicles has fallen in real terms.

Similarly, today in Europe, increasingly tight emissions standards for diesel emissions are coming into force, and the industry is again meeting these challenges cost effectively.

[10] *The Cost-Effectiveness of Further Regulating Mobile Source Emissions*, Sierra Research Inc.,1994.
[11] *Honda Meets a Strict Emission Rule*, The New York Times,1995.
[12] *On the Accuracy of Regulatory Cost Estimates*, W. Harrington, R. Morgenstern, P. Nelson (Resources for the Future), 1999. Citing *The Cost of Emission Controls on Motor Vehicles and Fuels: Two Case Studies*, Cackett, presented at the 1998 Summer Symposium of the EPA Center on Airborne Organics, MIT Endicott House, Dedham, Mass July 9-10, 1998.

Longer-term aims

2.43 In addition to the 2012 vehicle efficiency target discussed above, the European Parliament has indicated that it would like to set longer-term targets for 2020 and 2025. The Review is supportive of efforts to bring in regulation for 2012, because shorter-term reductions are particularly valuable in combating climate change and the technology required to meet the 2012 target is already available. But the Review also believes that it will be important to give industry more time to prepare for the next set of targets so that manufacturers can plan for the next model cycle with certainty about the trajectory required. The United States Congress has set a target of 35mpg for the average vehicle sold by 2020 (equivalent to approximately 180g/km for a petrol car), with yearly targets to be set from 2011 for five model years initially, with differentiation of targets by vehicle size. The Canadian Ministry of Transport has indicated that Canada will regulate for standards at least as stringent as the US.

Medium-term target

2.44 The Prime Minister's speech on Climate Change of 19th November 2007 at the Foreign Press Association in London cited the technical assessment of the King Review Part I – that a halving of average emissions by 2030 to around 80 grammes per kilometre is feasible – and went on to state that: "Britain will now press for a second ambitious European target of 100 grams per kilometre by 2020, or no later than 2025".[13]

2.45 In the medium term a sales weighted average target of 100g/km by 2020 appears to be realistic technologically, and is sufficiently close to stimulate the development of models to meet it. The Review therefore recommends that the EU set a target of 100g/km for 2020.

Recommendation 3: The EU should adopt a 100g/km new car sales weighted average target for 2020.

Longer-term target

2.46 Beyond the 2012 and 2020 targets, it is important that the EU continues to send strong signals to the motor industry that it will continue to regulate for substantial cuts in emissions, and that major technological change will be needed to sell motor vehicles in Europe by 2030. The Review therefore recommends that the EU regularly sets targets into the future to provide continued certainty on the need for further reductions in emissions.

Recommendation 4: The EU should set in place a process for regular target setting every 7-10 years (or in line with future model cycles) to ensure that the industry can invest in and bring CO_2 saving technologies to market with certainty about the standards that the EU will require.

CO_2 from production and disposal will become more important

2.47 While reducing the emissions from the use of vehicles has been the primary focus of efforts so far, it is also important to consider the carbon generated during the production and disposal processes, particularly from the energy used. As tailpipe emissions fall over time – as a result of engine efficiency improvements, and the use of alternative fuels and batteries – CO_2 emissions from production and disposal will become proportionately more important, assuming they do not decline at a similar rate. As set out in the King Review Part I emissions from production and disposal currently account for about 15 per cent of CO_2 emissions from the life cycle of a vehicle. If emissions from the use of the vehicle (i.e. fuel consumption) fell to 50 per cent of current levels, the proportion of emissions due to production and disposal of the car would be likely to rise from 15 per cent to about 26 per cent.

[13] Prime Minister's Speech on Climate Change, November 2007, http://www.pm.gov.uk.

2.48 Within the next 10-20 years competitively priced plug-in hybrid vehicles may begin to emerge. The overall emissions of these vehicles are heavily dependent on how the car is used (e.g. the length of journeys, how often the battery is charged) and the source of electrical power from which the car is charged; therefore tailpipe emissions may become a misleading or redundant measure of assessing the fuel consumption of a car.

2.49 Methods of production and disposal may also change quite substantially if, for example, revolutionary materials are used in producing batteries, or new lightweight materials are used in the architecture of the car. It will be important to ensure that in "rethinking the car", the measurement of tailpipe emissions evolves to ensure that the emissions and the broader environmental impact of production and disposal are not ignored and that the sustainability of new methods is captured. In the long term, emissions targets will need to capture all CO_2 emissions from manufacturing and disposal, powering/fuelling and use of the car, not just emissions from the tailpipe.

Recommendation 5: The Department for Transport, working with the European Commission, should work to design a CO_2 target for vehicles that captures the full CO_2 impact of vehicle production, disposal, usage and the production of the fuel or power used by the car.

CONCLUSION

2.50 Vehicle technologies are likely to represent a more cost effective source of reducing emissions than fuels within the next few years, and there are also good longer term prospects for substantial reductions. Government intervention at the UK, EU and international levels can ensure that technology which leads to lower CO_2 emissions is made widely available in cars. It is important to continue to strengthen supply side measures, as have been used over a number of years across the world, to bring forward lower emissions vehicles to market as quickly as possible.

3 Cleaner fuels

INTRODUCTION

3.1 As the King Review Part I set out, reducing total carbon emissions in the UK by 60–80 per cent by 2050 will be a major challenge and will require almost total decarbonisation of the road transport sector. Savings from improving vehicle efficiency and smarter consumer choices can make a major contribution to reducing CO_2 but, ultimately, fully decarbonising road transport will require the widespread adoption of carbon-free fuels. Importantly, the push to decarbonise fuels can also complement efforts to improve the UK's energy security, reducing our dependence on finite fossil resources such as oil.

3.2 In the short term, whilst the internal combustion engine remains dominant, the scope for decarbonising fuels is likely to be largely determined by production of sustainable low-carbon biofuels as other low-carbon fuels cannot be widely used in the current vehicle stock. Given the significant land requirements of current biofuels, it is likely to be difficult to reduce the carbon intensity of fuels by more than 5-10 per cent over the next 10-15 years without risking significant land-use change. However, in the longer term, there is significant scope to decarbonise fuels through the use of electricity (batteries) and hydrogen (produced in a low-carbon way) as well as through biofuels with very low land requirements. By 2050, a "carbon-free" fuel mix is a possibility – although this is likely to be largely dependent on the degree to which electricity generation can be decarbonised and will also require significant developments in vehicle technology.

KEY POLICY CHALLENGES

3.3 This section outlines four key challenges for reducing CO_2 emissions from road transport fuels:

- reducing CO_2 from fuels **efficiently**;
- reducing CO_2 from fuels **sustainably**;
- ensuring an effective and fair **global** market for fuels; and
- **enabling** effective expansion of low-carbon fuels.

Reducing CO_2 from fuels efficiently

3.4 There are many different routes to decarbonising road transport fuels, including through increased use of biofuels, electricity, hydrogen and alternative fossil fuels such as liquid petroleum gas (LPG) and compressed natural gas (CNG) as well as by limiting the emissions from production of petrol and diesel. To ensure road transport fuels are decarbonised cost-effectively, it is important that policy provides flexibility and proportionate incentives for all methods of decarbonising the fuel mix.

3.5 Effective and efficient environmental policy should allow flexibility for CO_2 to be reduced in the areas and sectors where the greatest impact can be achieved for the lowest cost in the long term. In the case of road transport it is important that the balance between action on fuels and vehicle efficiency is such that the overall costs of reducing carbon from the sector are minimised. More broadly, policy should also allow flexibility for CO_2 to be reduced efficiently across all sectors of the economy, ensuring CO_2 is reduced in the areas where this is least costly. Any action on road transport fuels should be consistent with this. However, given the challenge of an 60-80 per cent reduction in CO_2 emissions by 2050, no sector which is a major contributor to CO_2 emissions, such a road transport, will be able to avoid making major reductions.

Reducing CO_2 from fuels sustainably

3.6 All fuels need to be developed sustainably, limiting wider environmental impacts as well as CO_2 emissions. This issue is particularly relevant for biofuels. As discussed in the King Review Part I, rapid expansion of biofuels production could have major environmental impacts, such as land-use change, and social impacts, such as increased food prices. Sustainable development of biofuels is therefore a major challenge for policy. There are two key aspects to this:

- **setting a sustainable level of ambition**. Targets and obligations affecting biofuels must be set responsibly – balancing the need to encourage innovation and industry development against the risks of adverse environmental and social impacts if production is expanded too rapidly; and
- **ensuring more sustainable biofuels are developed**. Developing biofuels that have limited direct effects on the environment – such as on land-use and water supply – is a priority. In addition, policy must address the indirect effects of biofuels production – where biofuels production on existing agricultural land can displace the incumbent use into other areas, potentially inducing damaging land-use change or increasing food prices. To limit this effect, biofuels that use very low amounts of productive agricultural land (such as those produced from waste or agricultural residues) should be encouraged along with general policies to prevent environmentally damaging land-use change around the world. More robust methods to determine the environmental impacts of fuels also need to be developed.

Establishing an effective and fair global market for fuels

3.7 A global market for fuels already exists. However, as the use of alternative fuels such as biofuels increases, measures are needed to ensure the global market functions effectively, fairly and sustainably. Key issues include:

- ensuring the overall global level of demand for biofuels is sustainable;
- avoiding the problem of "shuffling" where fuel suppliers are incentivised to divert their low-carbon fuels to sell in countries with the most stringent regulation and switch sales of their high-carbon fuels away from these countries, limiting the impact of environmental policy;
- establishing an internationally agreed carbon and sustainability reporting methodology to allow fair differentiation between fuels with different environmental impacts and help develop a sustainable global market; and
- reducing barriers to trade such that fuels are produced where this can be carried out most efficiently.

3.8 To address these issues, global efforts are needed to coordinate policies and reduce barriers to trade.

Enabling effective expansion of low-carbon fuels

3.9 Measures to enable the expansion of low-carbon fuels will also be needed. For example, effective expansion of biofuels will require vehicle and fuel developments to allow higher blends to be used in the vehicle stock. The effective use of electricity as a car fuel will require measures to ensure consumers can charge vehicles conveniently and at times of day when the CO_2 impacts are low.

CURRENT POLICY CONTEXT

3.10 In recent years, the UK and Europe have taken a number of steps to encourage alternative fuels. These efforts have been driven both by the need to reduce CO_2 from road transport and to reduce the oil dependence of the road transport sector.

EU targets

3.11 The level of ambition on alternative fuels in the UK has been set at a European level, through targets. In 2003, the Biofuels Directive set an indicative target for biofuels to represent a 5.75 per cent share (by energy content) of petrol and diesel consumption by 2010. At the 2007 Spring Council, EU Member States then agreed a target for biofuels to represent a 10 per cent share of petrol and diesel consumption by 2020 to be set within the Renewable Energy Directive (RED) – subject to the sustainability of production and commercial availability of second generation biofuels.[1]

3.12 Further to this, the European Commission has also proposed a target for fuels that is explicitly linked to carbon emissions within the Fuel Quality Directive (FQD). As currently proposed, this would require that the average life-cycle emissions (carbon intensity) of fuels sold be reduced by 10 per cent by 2020. As discussed later in this chapter, meeting a 10 per cent carbon reduction target for fuels potentially requires high volumes of biofuels, raising sustainability concerns.

UK policies

3.13 At present, the UK's primary means of meeting the EU targets are the Renewable Transport Fuels Obligation (RTFO) and favourable fuel duty differentials for alternative fuels. The RTFO will, from April 2008, place an obligation on fuel suppliers to ensure that a certain percentage of their aggregate sales is made up of biofuels. The effect of this will be to require 5 per cent of all fuel sold on UK forecourts to come from a renewable source by 2010. The Department for Transport (DfT) has also announced that, from April 2010, the RTFO will reward biofuels according to the carbon savings they offer (rather than simply stipulating a volume) and, from 2011, will reward only those biofuels which meet sustainability criteria. Alternative fuels are also encouraged through fuel duty differentials – biofuels receive a 20 pence differential per litre over petrol and diesel, whilst liquid petroleum gas (LPG) and compressed natural gas (CNG) also receive favourable duty differentials.

[1] And the Fuel Quality Directive being amended to allow adequate levels of blending.

The wider challenge

3.14 Efforts to decarbonise fuels and road transport will contribute to the wider context of reducing emissions across the UK, European and global economies. The UK has committed to a target of at least a 60 per cent reduction in total CO_2 emissions by 2050[2] whilst the EU has committed to a 20 per cent reduction by 2020 (rising to 30 per cent if a global agreement is reached). The EU Emissions Trading Scheme (EU ETS) is the EU's principal tool for achieving this target.[3] The EU ETS currently covers energy intensive industries such as electricity generation, iron and cement as well as oil refineries and platforms in Europe. The EU is also considering expanding the scheme to more sectors – such as aviation and, potentially, road transport.

Table 3.1: Summary of Key Fuel Policies and Targets

EU Targets		
Renewable Energy Directive (RED)	**10 per cent minimum target for the share of biofuels in overall petrol and diesel consumption by 2020** (by energy content)	Member States are responsible for delivering this target with the policy mechanisms of their choice
Fuel Quality Directive (FQD)	Proposes a **10 per cent reduction in average life-cycle emissions of fuels between 2010 and 2020**	Fuel suppliers are responsible for delivering this target
UK Policies		
Renewable Transport Fuel Obligation (RTFO)	Requires fossil transport fuel suppliers to ensure that **5 per cent of their aggregate sales are from renewable sources by 2010/11**	The Department for Transport has stated that it will reform the RTFO to reward biofuels based on CO_2 savings by 2010
Fuel Duty differentials for alternative fuels	– Biofuels: 20 pence per litre duty incentive (until at least 2009/10) – Biogas: Incentive of over 40 pence per litre (until at least 2011/12) – LPG and CNG also receive fuel duty discounts	

REDUCING CO_2 FROM FUELS EFFICIENTLY

There are many ways of decarbonising the fuel mix

3.15 As the King Review Part I set out, there are a number of ways of decarbonising the fuels mix, both through fuel switching and by reducing CO_2 involved in the production of fuels. The following illustrates the range of opportunities and risks in reducing the CO_2 emissions from fuels:

- **reducing or limiting emissions in producing fossil fuels such as petrol and diesel.** Currently the emissions from extracting and refining petrol and diesel are approximately 15 per cent of total life-cycle emissions. Therefore, the scope to reduce emissions from production may be limited (although reductions in "flaring" could make a significant difference). Conversely, a key concern is that extraction/production emissions could increase as unconventional sources of

[2] Subject to the Climate Change Bill being passed.

[3] Emissions trading (or "cap and trade") works by setting a limit on total allowed CO_2 emissions, but allows individual emitters to trade allowances within this cap.

petrol and diesel such as oil sands and coal begin to be exploited (petrol from oil and tar sands has life-cycle emissions that are 15-170 per cent higher than that from conventional sources[4] and Canadian oil sands represent 14 per cent of global proved oil reserves[5]). Avoiding the consequent increase in emissions from unconventional oil is a key challenge for policy;

- **increased use of alternative fossil fuels** such as LPG and CNG which can both offer small but significant life-cycle CO_2 savings over petrol and diesel. Cars capable of using LPG or CNG currently represent less than 1 per cent of the total car stock but there is scope to expand their use;[6]
- **increased use of biofuels**. Some biofuels offer significant CO_2 savings whilst others offer very limited or even no savings. Therefore, the amount of CO_2 that can be saved through biofuel use will depend both on ensuring low-carbon biofuels are used, and on increasing sustainable supply capacity by developing feedstocks that minimise the use of productive agricultural land;
- **increased use of electricity to power cars**. Electricity produced from any primary energy source, with the exception of coal, is likely to offer significant CO_2 savings compared with petrol and diesel. Electric-powered cars could become increasingly prevalent in the future – for example, plug-in hybrids, running partly on electricity, could be commercial within 10-15 years;
- **increased use of hydrogen**. Hydrogen produced from low-carbon sources can offer large carbon savings compared with petrol and diesel. In the short term, the scope to reduce the carbon intensity of the fuel mix through hydrogen is limited by the lack of availability and high cost of low-carbon hydrogen (except in special cases such as from intermittent electricity generation at times of day when there is no other use for that power) along with the lack of available vehicles and supply infrastructure; and
- there may also be scope for future **innovative future fuel developments** to contribute to CO_2 reductions from fuels.

Fuels should be incentivised based on life-cycle CO_2 emissions

3.16 As the above paragraph demonstrates, *how* a fuel is produced can be as important in determining CO_2 emissions as *what* fuel is produced. There are many different ways of producing the same fuel, resulting in markedly different life-cycle CO_2 emissions (see the King Review Part I). The challenge for policy is therefore to ensure all fuels are incentivised based on their life-cycle CO_2 emissions. Establishing more robust and verifiable methodologies for assessing the life-cycle CO_2 emissions of all fuels will be crucial in achieving this.

3.17 Currently, the main policy instruments in the UK for reducing the carbon intensity of fuels are the RTFO and fuel duty differentials for alternative fuels. These policies help reduce the carbon intensity of the fuel mix because they provide incentives for fuels which are generally lower carbon over their life cycle than petrol and diesel. However, CO_2 emissions vary depending on how each fuel is produced and the incentives that fuel duty and the RTFO currently provide do not reflect this.

[4] *A Low Carbon Fuel Standard for California, Part 1: Technical Analysis*, Institute of Transport Studies, UC Berkeley, 2007.
[5] *BP Statistical Review of World Energy*, BP, June 2007.
[6] SMMT, UKLPG.

A carbon-linked RTFO

3.18 In recognition of this, DfT has announced that from April 2010, biofuels will be rewarded under the RTFO according to the carbon savings they offer. This is an important and welcome reform since, as discussed in the King Review Part I, the life-cycle carbon emissions of biofuels vary widely depending on feedstocks used, farming method and production technique. Under a carbon-linked RTFO, biofuels with lower life-cycle emissions could receive more credits. To achieve this a robust and enforceable methodology for measuring the life-cycle emissions of different biofuels needs to be agreed. In February 2008 the DfT released guidance on carbon reporting within the RTFO.[7]

Allowing greater flexibility for decarbonising fuels

Reducing the carbon-intensity of fuels at least cost

3.19 UK policy should allow flexibility and incentives for all routes to reduce the carbon-intensity of fuels. At present there is a risk that policies in the UK, Europe and beyond are focusing on biofuels at the expense of other alternatives. In this way, other potentially lower-cost routes to decarbonising fuels may be disadvantaged, increasing the overall costs of reducing CO_2 from fuels. Moreover, any reductions in emissions from increased use of alternative fuels could be eroded by increases in emissions resulting from greater use of unconventional oil.

3.20 While a carbon-linked RTFO is a major step towards efficiently decarbonising fuels, at present it is only a mandate for biofuels (although in principle, any completely renewably produced fuel could qualify[8]). As discussed in paragraph 3.15, increased use of biofuels is only one of a number of possible ways to achieve reductions in CO_2 emissions from fuels.

The case for a Low Carbon Transport Fuel Obligation

3.21 To provide a more "level playing field" for competing fuels (and competing methods of producing those fuels) and greater assurance over total emissions from fuels, options to include more, and ideally all, fuels in mandates such as the RTFO should be considered. To include all fuels, one possible option is to reform the RFTO so that it becomes a Low Carbon Transport Fuel Obligation (LCTFO), expressed as a mandate to reduce the carbon-intensity[9] of fuels by 10 per cent by 2020 (giving equivalence to the EU FQD target[10]). A LCTFO could be enforced through an "emissions reduction credit" scheme. This would be a tradable credits scheme where fuels that have lower carbon intensity than the target generate credits that can be sold to producers of fuels that are above the target. California's Low Carbon Fuels Standard is an example of such a scheme (see Box 3.1).

3.22 A LCTFO would allow the carbon-intensity of fuels to be reduced at least cost. Fuel suppliers would be able to purchase credits generated by other firms if this was cheaper than reducing their own emissions, therefore ensuring carbon was reduced from fuels where this was least costly. Importantly, a LCTFO would provide incentives not only to reduce emissions, but also to avoid increases in emissions, such as by developing unconventional sources of petrol and diesel with high extraction and production emissions.

[7] *Carbon reporting within the Renewable Transport Fuel Obligatiion – Methodology*, E4tech, 2008.

[8] In practice, it may be difficult for fuels other than biofuels to qualify. For example, for electricity to qualify it would need to demonstrate that it was completely renewably generated which would be difficult given that the grid is supplied from a mixture of different sources; fossil, nuclear, and renewable.

[9] Defining carbon intensity would be a key issue in designing a LCTFO. If the LCTFO were based strictly on carbon emissions per unit of energy in the fuel, it would be biased against fuels that are used in more energy efficient vehicle drivetrains. For example, electric motors are far more efficient in converting energy to wheel power than petrol engines. Thus, the carbon intensity metric should take into account inherent efficiency differences between fuels with adjustment factors (see *A Low-Carbon Fuel Standard for California – Part 2: Policy Analysis*, Farrell, A. & Sperling, D., 2007).

[10] At present the use of electricity cannot contribute to the FQD target although this may be amended in the future.

Greater assurance over climate change goals

3.23 Since a LCTFO would give policy-makers greater control over the carbon-intensity of the fuel mix, it could help ensure greater certainty over meeting UK carbon budgets. Moreover, by encouraging fuels other than biofuels to contribute to meeting the FQD target, the risks around sustainability would be reduced (see paragraph 3.41). When assessing the case for a LCTFO, it will be important to consider how it would interact with other policies such as the EU Emissions Trading Scheme[11] and existing fuel duty differentials.[12]

Box. 3.1 California's Low Carbon Fuel Standard

In January 2007, Governor Schwarzenegger announced the Low Carbon Fuel Standard (LCFS) for California, requiring fuel suppliers to reduce life-cycle carbon intensity of fuels sold by 10 per cent by 2020 (equivalent to the EU's Fuel Quality Directive target). To deliver this, an 'emissions reduction credit' scheme is being established – fuels which have lower carbon intensity than the target generate credits which can be sold to those fuels which are above the target.

The LCFS is a policy that is "technology neutral" (between fuels), catering for all possible futures. In this way, it helps different fuels technologies such as biofuels, hydrogen, electricity, LPG, CNG and any potential new fuels to compete on a level playing field.

Electricity companies will have a choice to opt in to the LCFS and in practice they are expected to do so as electricity from most sources is likely to be lower-CO_2 than the target and therefore earn credits. This is a potentially important step in getting electricity companies actively engaged in providing their product as a transport fuel – particularly in providing complementary infrastructure such as fast charging points and smart metering.

3.24 As a matter of principle, fuels policies should allow flexibility for as wide a range of routes to decarbonisation as possible. In the future, targets in the UK, EU and internationally should be explicitly focused on the goal of CO_2 reduction rather than mandating volumes of a specific fuel type such as biofuels.

[11] Electricity suppliers, oil refineries and offshore platforms/terminals within Europe are subject to the EU Emissions Trading Scheme and must purchase allowances to cover the CO_2 emissions from their facilities. Thus, these entities could be regulated twice if a LCTFO was introduced.
For electricity suppliers, a LCTFO would most likely be financially beneficial, as most electricity would have lower life-cycle emissions than the obligation requires. Therefore, electricity suppliers would have an incentive to opt into the scheme since they could earn credits. Importantly, this would also give electricity firms more incentive to help introduce infrastructure important for the development of electric vehicles, such as dedicated "fast-charging" points and smart metering (see Box 3.1). Without a LCFTO, and the opportunity to earn credits, electricity suppliers may have some disincentive to supply "extra" electricity for transport given that their overall emissions are already "capped" under the EU ETS.
Unlike electricity providers, refineries and offshore platforms/terminals within Europe would not financially benefit from inclusion in a LCTFO as well as the EU ETS, as the life-cycle emissions of petrol and diesel would be higher than the obligation requires. One option to avoid "double-regulation", would be to allow oil refineries to opt out of the EU ETS so long as they comply with the LCTFO (or vice versa). However, to avoid disrupting the EU Emission Trading Scheme, the pragmatic solution may be to leave these entities subject to both schemes. One major advantage of a LCTFO is that it offers the opportunity to regulate emissions from the production of petrol and diesel outside Europe. This could become increasingly important as unconventional sources such as Canadian oil sands, which involve high extraction and production emissions, are developed.

[12] Alternative fuels such as biofuels, LPG and CNG currently receive fuel duty discounts to incentivise their use. Any implementation of a carbon-linked RTFO or a LCTFO would need to consider the interaction with these fuel duty differentials.

Recommendation 6: The Department for Transport should assess the case for a mandate to reduce the carbon intensity of the fuel mix covering all fuels, through a Low Carbon Transport Fuel Obligation, alongside other options to link the Renewable Transport Fuels Obligation to life-cycle CO_2 emissions already under consideration. The obligation should be enforced through a system of tradable credits.

Reducing carbon from road transport cost-effectively

3.25 At present, the UK and Europe have both fuel targets (such as the RTFO and the FQD) and a vehicle target (EU new car CO_2 targets). Both sorts of target aim to reduce CO_2 emissions from road transport. But it is not clear that separate fuel and vehicle targets will deliver reductions at least cost. Depending on the future structure of the policy instruments used to deliver the targets, some linking of fuel and vehicle targets may be possible and desirable. For example, by allowing trading of credits between schemes, fuel suppliers could pay vehicle manufacturers to reduce emissions on their behalf if this was mutually beneficial.[13] This would allow flexibility for emissions to be reduced in the area where these reductions can be achieved at least cost, lowering the overall costs of decarbonising road transport. Importantly, any flexibility should not allow scope for the overall level of CO_2 reduction to fall.

The balance between fuels and vehicles targets

3.26 In the absence of flexibility between targets, policy-makers should ensure that targets are balanced such that the overall cost of reducing carbon from road transport is minimised. Currently, the fuels targets imply relatively high abatement costs (for example, biofuels can typically cost £90-£150 per tonne of CO_2 abated[14]) whereas, as Chapter 2 shows, action on vehicle efficiency is likely to be cost saving (as the extra technology cost is outweighed by the fuel cost savings over the life of the vehicle). Moreover, the risks in relation to sustainability of over-ambitious fuel targets are high (see paragraph 3.39). Thus, in the short term, it is preferable to strengthen vehicle targets relative to those on fuels.

Recommendation 7: The European Commission should develop policy instruments to provide flexibility between fuel and vehicle targets, such as allowing trade of credits between targets. In the absence of flexibility between targets, EU mandates on fuels and vehicles should be balanced such that the overall costs of reducing CO_2 emissions are minimised – at present, this suggests vehicle targets should be more stringent relative to fuel targets.

Ensuring that decarbonising fuels is consistent with cost-effective CO_2 reduction across the economy

A single price of carbon minimises abatement costs

3.27 Climate change policy should aim to reduce carbon across the economy at least cost over the long term. Road transport must compete with other sectors (such as heat and power) for scarce low-carbon energy sources. The challenge for policy is to ensure that low-carbon energy sources are put to most efficient and effective use, so that the costs of reducing CO_2 are minimised across the

[13] Allowing trading of credits between fuels and vehicles mandates would require a single unit of measurement. Vehicle efficiency is generally measured in gCO_2/km whereas any fuel mandate in the future will most likely be based on CO_2 per unit energy. To allow a common measure for credit trading, both measures could be converted into "tonnes of CO_2". In the case of vehicle efficiency, this would require an estimate on how many kilometres the vehicle travels over its life.

[14] *Well-to-wheels analysis of future automotive fuels and powertrains in the European context*, CONCAWE/EUCAR/ECJEC, 2007.

economy. At present, the policy framework does not guarantee this. For example, by placing specific targets on fuels (such as in the RTFO, RED and FQD) there is a risk that the road transport sector may begin to consume too much biomass relative to other sectors such as heat and power. Under current oil and coal prices, using biomass for heat and power saves CO_2 more cost-effectively than using it for transport[15] – and independent of oil and gas prices, biomass used in heat and power saves more CO_2.

3.28 At present, reducing carbon from transport fuels is, in general, more expensive than reducing carbon from other sectors such as power (although in some cases, such as through the use of some types of Brazilian sugar cane ethanol, carbon can be reduced at little or no extra cost). In future, improvements in fuel technology and changes to relative energy prices could change this situation. To allow for varied and changing abatement costs across sectors, policy needs to be flexible, allowing market mechanisms to determine where carbon abatement is most cost effective. As outlined in the Stern Review,[16] this requires a single price on carbon across sectors, such that incentives to reduce carbon are equalised across the economy.

The EU ETS provides a single price on carbon

3.29 The EU Emissions Trading Scheme (EU ETS) is one instrument that provides a single price of carbon for the sectors it regulates, along with flexibility on where emissions are reduced. Emissions trading (or "cap and trade") works by setting a limit on total permitted carbon emissions, but allows individual emitters to sell allowances if they achieve greater emissions reductions than anticipated, or to buy additional allowances from others if it is less costly than reducing their own emissions. The EU ETS currently covers energy intensive industries such as power, iron and cement, representing 46 per cent of UK CO_2 emissions.

Box 3.2: The spectrum of options for regulation to decarbonise fuels

Level of Regulation	Description	Examples
1. A biofuels volume obligation	A volume of biofuels in the mix is mandated	The UK Renewable Transport Fuels Obligation
2. A carbon-linked biofuels obligation	As above, with biofuels that offer greater carbon savings earning more credits	The UK government is committed to a carbon-linked RTFO by 2010
3. A carbon-intensity obligation for all fuels	A reduction in the carbon-intensity (CO_2/Joule) is mandated. The target is delivered through a system of tradable credits for all fuels	California's Low Carbon Fuels Standard
4. A wider road transport obligation	One option to do this would be to link mandates on the carbon-intensity of fuels with those on vehicle efficiency (possibly through tradable credits)	
5. Including road transport in an economy-wide obligation	Including road transport in the cross-sectoral "cap and trade" schemes (e.g. the EU Emission Trading Scheme)	Australia has proposed an emissions trading scheme which includes road transport

[15] *UK Biomass Strategy*, DEFRA/DTI, 2007.
[16] *The Stern Review on the Economics of Climate Change*, 2006.

Including Road Transport in the EU ETS

3.30 In future, road transport could be covered by a "cap and trade" scheme such as the EU ETS by making fuel suppliers the regulated entity.[17] Fuel suppliers would be required to hold EU ETS permits to cover the life-cycle emissions of all the fuel they sell. They could respond by either switching to fuels with lower life-cycle CO_2 emissions, or buying permits and transferring some or all of this cost to motorists as a "carbon price" in the fuel.

Carbon reduction at a lower cost

3.31 Including road transport in the EU ETS would mean another 21 per cent of the UK's carbon emissions would be covered by the scheme. The amount of emissions saved would depend on the number of allowances issued – and the extent to which purchase of Clean Development Mechanism (CDM)[18] credits from outside the EU was allowed. If the amount of extra permits allocated to the EU ETS to accommodate the road transport sector was restricted sufficiently, CO_2 emissions would fall. Emissions would either be reduced directly – through fuel switching, use of more efficient vehicles, or a reduction in demand – or indirectly – through purchase of permits from other sectors. Since the EU ETS allows carbon emitters to purchase abatement from where it is less costly, the overall cost of reducing carbon across the economy should fall.

The road transport and power sectors will become increasingly integrated

3.32 In future, developments such as electric-powered cars and electricity production as a by-product of biofuels will make it increasingly difficult to separate the road transport and power sectors. Thus, having a single instrument to regulate both sectors, such as the EU ETS, may become increasingly appropriate. Including road transport in an economy-wide trading scheme would also provide continuous incentives for fuel suppliers to reduce the carbon-intensity of the fuel they sell, in contrast to "fuel-specific" mandates such as the RTFO that cannot provide any incentives beyond meeting the target.

The importance of strengthening the EU ETS

3.33 The case for including road transport in the EU ETS is relatively strong. However, at present, the EU ETS price is very low (approximately £10-£15 per tonne of carbon[19]), whilst the cost of carbon abatement through reducing carbon from transport fuels is generally high and demand for car travel is relatively fuel price inelastic. Thus, the immediate effect of including road transport in the EU ETS would likely be that the sector buys credits from other sectors or through the CDM rather than cut emissions within the sector. Without complementary measures such as the RTFO and fuel duty differentials, this would leave fuel suppliers with little incentive to develop low-carbon alternative fuels. In the short term, it may be cost effective to allow most abatement to occur in other sectors. However, in the long term, major CO_2 savings from fuels are essential and it is important that the fuel technologies needed to achieve this begin to be developed immediately. For this reason, establishing a scarcity of permits and a stable price in the EU ETS should be priority as inclusion of the road transport sector in the scheme is considered.

[17] The other options to include road transport in the EU ETS would be to regulate vehicle manufacturers or motorists. To regulate vehicle manufacturers it would be necessary to make estimates of the expected lifetime emissions from the vehicles they sell rather than base regulation on actual emissions. This would risk undermining the integrity of the EU ETS and would provide little or no incentive for decarbonising fuel or reducing travel demand. Regulating motorists would involve allocating EU ETS permits to motorists and require them to surrender permits (to cover the emissions from the fuel they buy) when they buy fuel. This would place an implicit carbon price on fuels sold and it would therefore have a similar effect to regulating fuel suppliers. However, whereas regulating fuel suppliers would involve issuing permits to a limited number of suppliers, regulating motorists would require issue of permits to a very large number of individuals implying high administration and transaction costs.

[18] The Clean Development Mechanism (CDM) is linked to the EU ETS as part of the flexible mechanisms developed under the Kyoto Protocol. This link allows emitters within the EU ETS to invest in projects in developing countries that reduce emissions at lower cost, and credit these emissions reductions against their own limit. The CDM therefore allows finance to flow from richer countries to developing countries, providing funds for investment, and facilitating the transfer of technology and expertise.

[19] www.pointcarbon.com.

Other policies are still likely to be needed

3.34 Including road transport in a trading scheme such as the EU ETS would not be a total solution to tackling carbon emissions from the sector. As consumers heavily discount future cost savings from fuel efficiency, complementary action is likely to be needed to encourage production and purchase of efficient vehicles, on both the demand and supply side (see Chapters 2 and 4).

3.35 While including road transport in a trading scheme would ensure that the carbon contained in fuels used is priced into the market, it is important to note that there are many other major externalities associated with road transport such as local air quality, noise, accidents and congestion. These will still need to be accounted for through other pricing instruments such as fuel duty.

Taxation can have similar effects to emissions trading

3.36 Taxation (i.e. fuel duty) is already used to price carbon in the transport sector and it has a significant impact on demand and incentives for alternative fuels. In this way, it can have a similar effect on CO_2 emissions from the sector to that of including road transport in a trading scheme. However, there are also important differences. For example, including road transport in the EU ETS has advantages over tax with regard to establishing a single price for carbon across sectors and across countries, as well as in providing consistent incentives across the life cycle of fuels. Tax has advantages with regard to simplicity, revenue flexibility, stability and tax sovereignty.

Meeting the UK's Carbon Budgets

3.37 The Climate Change Bill will make the Government's carbon dioxide emission reduction target of at least 60 per cent by 2050 legally binding for the first time. It will also put in place five-yearly milestones called carbon budgets. The extent to which the UK Government can directly control carbon emissions is therefore likely to become an increasingly important issue in the future. Including road transport in the EU ETS could give the UK greater control over emissions, as those from the included sectors would be "capped".[20] If road transport was included in the EU ETS, the RTFO (or a LCTFO) could still be retained although this would reduce flexibility and therefore potentially reduce the overall cost effectiveness of carbon reduction.

Recommendation 8: The UK Government should assess the case for inclusion of road transport in trading schemes such as the EU Emissions Trading Scheme (with fuels suppliers as the regulated entity).

Decarbonising electricity

3.38 Given that, in the longer term, decarbonising road transport is likely to be heavily dependent on decarbonising electricity generation, it is essential that the UK and EU have in place the policy framework that can deliver this objective. A strengthened EU ETS has a major role to play in decarbonising the electricity generation sector.

ENSURING FUELS ARE DECARBONISED SUSTAINABLY

3.39 All fuels need to be developed sustainably, limiting their wider environmental and social impacts as well as CO_2 emissions. In the short term, biofuels are a key option for decarbonising fuels. However, they present a major sustainability challenge – particularly in ensuring their production does not increase the global rate of environmentally damaging land-use change. Other fuels also present sustainability challenges – for example the development of oil sands can have damaging effects on land-use and water supply. There are two key aspects to decarbonising fuels sustainably: (i) ensuring a sustainable level of ambition; and, (ii) developing fuels with lower overall impacts on the environment (including identifying, agreeing and verifying methods for determining the sustainability of a fuel).

[20] Permits the UK allocates to the EU ETS are likely to count towards the carbon budgets rather then actual emissions. Thus if any sector such as road transport increases emissions through purchase of additional allowances on the EU ETS this can be treated as "offsetting".

A sustainable level of ambition

3.40 The level of ambition for alternative fuels should not run ahead of measures to limit any negative environmental impacts they cause. In particular, to ensure biofuels are developed sustainably, production should not be expanded ahead of advances in technology, and the development of robust, verifiable safeguards, to minimise their environmental and social impacts. Therefore, it is important that targets affecting biofuels are not overly ambitious in the short term. At present EU targets on fuels imply significant increases in biofuel production up to 2020. The Renewable Energy Directive (RED) requires a 10 per cent share of transport fuel to be biofuels by 2020, whilst the Fuel Quality Directive (FQD) proposes a 10 per cent reduction in the carbon intensity of the fuel mix by 2020.

Reducing the CO_2 intensity of fuels by 10 per cent implies high volumes of biofuels

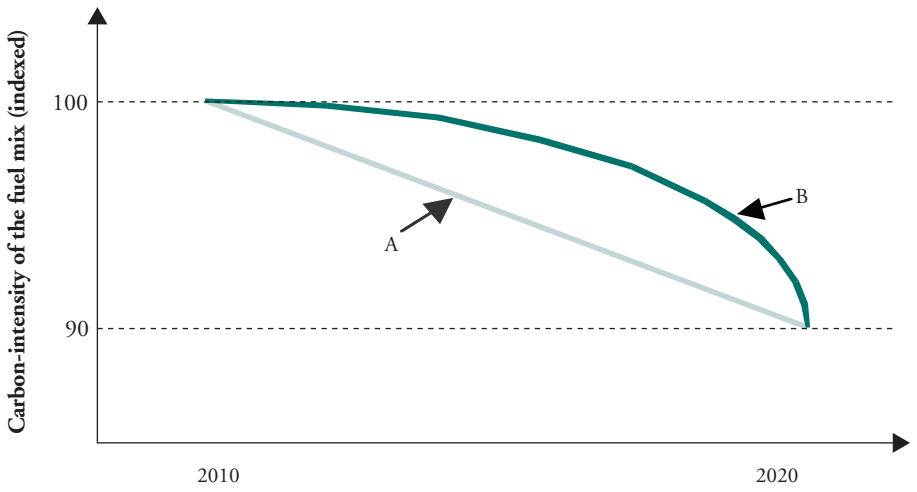
3.41 As currently proposed, the FQD will almost certainly be more challenging to meet than the RED. One of the most likely pathways for meeting the FQD target is through large increases in the volume of biofuels in the fuel mix. Since many of the cheapest biofuels offer 30-40 per cent carbon savings compared with petrol and diesel, meeting the FQD greenhouse gas target by increasing biofuels production could imply that they represent as much as 25-30 per cent of the fuels mix. With current technologies this would require large amounts of agricultural land converted or developed to produce biofuels, therefore risking major land-use change and consequent negative environmental impacts (see the King Review Part I).

A lower FQD target with a more gentle trajectory

3.42 In the future, biofuel technology will improve and highly land-efficient biofuels may become cost effective. However, there is uncertainty over when this will happen and therefore the European Commission should exercise caution in relation to fuels targets. There are two aspects to this as regards the FQD:

- **reducing the level of the FQD carbon target below 10 per cent**. A lower target would reduce the risks of major environmentally damaging land-use change from increased biofuels production. There is an opposing risk that the target is set too low relative to future low-carbon technology developments, and therefore potential benefits are missed. However, this is a small risk when weighed up against the risk of major land-use change if the target turns out to be too high. A cautious approach is therefore recommended; and
- implementing a **gentler trajectory** for the target in the earlier years (followed by a steeper trajectory towards 2020). Some of the least costly, readily available biofuels offer relatively low carbon savings and have significant land requirements. If the FQD target is too stringent in the early years there is a risk that current biofuel technology may become "locked-in" at the expense of better future technology. To help avoid this, the FQD should replace the currently proposed linear trajectory with a trajectory that provides for smaller changes in earlier years. Chart 3.1 sets this out, suggesting a movement from trajectory (A) to an accelerating trajectory (B). This would allow more time for innovation in biofuels with greater carbon savings and lower land and water requirements, increasing the chance of meeting the target sustainably (although the direct CO_2 savings achieved from fuels by 2020 would fall).

Chart 3.1: An alternative compliance trajectory for the Fuel Quality Directive



Reviewing the sustainability of EU targets

3.43 Both the FQD and RED targets present risks in relation to sustainability and therefore the targets levels should remain under review. In February 2008 the DfT commissioned the Renewable Fuels Agency to lead a study on the indirect effects of biofuels to inform future targets affecting biofuels after 2010. Leading up to 2020 there should also be further opportunities to review the level of the targets in response to any sustainability concerns, although any conditionality should be specified to avoid creating any unnecessary uncertainty for industry.

Recommendation 9: To reduce the risk of damaging land-use change from large increases in biofuels production, the EU Fuel Quality Directive target on CO_2 (requiring a 10 per cent reduction in the carbon intensity of fuels by 2020) should be revised downwards and a gentler compliance trajectory be implemented.

Encouraging sustainable biofuels

Encouraging sustainable biofuels

3.44 To allow expansion of biofuels without risking major damage to the environment and communities, it is vital that more sustainable biofuels are developed. Recognising this, DfT is developing a sustainability methodology for biofuels under the RTFO. DfT has proposed seven key principles in determining this:[21]

Environmental Principles:

1. biomass production will not destroy or damage large above or below ground carbon stocks;
2. biomass production will not lead to the destruction or damage of high biodiversity areas;
3. biomass production does not lead to soil degradation;
4. biomass production does not lead to the contamination or depletion of water resources;
5. biomass production does not lead to air pollution;

[21] *Carbon and Sustainability Reporting within the Renewable Transport Fuel Obligation*, DfT, 2007.

Social Principles:

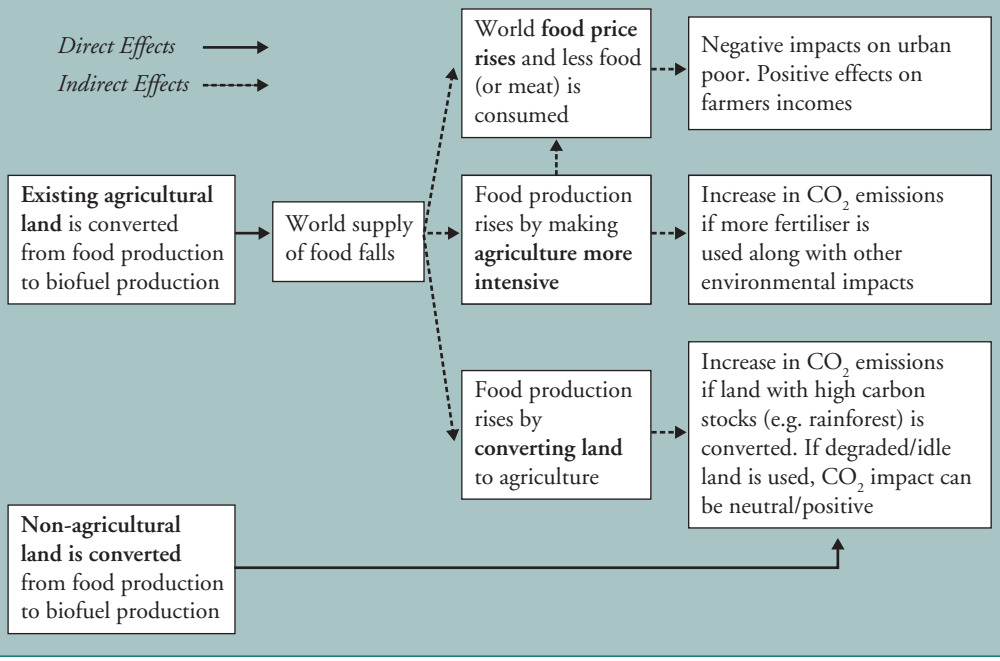
6. biomass production does not adversely affect workers rights and working relationships; and
7. biomass production does not adversely affect existing land rights and community relations.

3.45 As many biofuels are sourced from outside the UK and Europe, it is important to agree a set of sustainability criteria at an EU and international level. The EU Renewable Energy Directive aims for a complete harmonisation of biofuel sustainability criteria in order to ensure that differing criteria do not create obstacles to trade between Member States. At present a criterion for water use is not included in the RED proposals. This is a major concern given that some biofuel feedstocks are highly water-intensive; therefore growing biofuels in areas of water scarcity could exacerbate shortages.

Sustainability standards are an important step but not a total solution

3.46 Once sustainability criteria have been agreed, certification schemes and minimum standards using these principles can be established, improving the overall sustainability of biofuels supplied. From 2011, the Government aims to reward biofuels under the RTFO only if they meet appropriate sustainability standards. However, whilst such schemes help limit the direct sustainability consequences of biofuels production, they will not be able to address the indirect effects. As discussed in the King Review Part I, biofuels grown on existing agricultural land may displace the incumbent use – for example food production – into other areas (see Box 3.3). A particular concern is that this "displacement" effect could increase the rate of land-use change around the world, causing large releases of carbon stocks and loss of biodiversity. As long as environmental benefits such as carbon storage and biodiversity are not fully reflected in the value of land, there could be large negative environmental impacts resulting indirectly from the use of biofuels. As highlighted in the King Review Part I and the Stern Review, land use change currently accounts for up to 18 per cent of global emissions.

Box 3.3: Illustration of the indirect effects of biofuels



Dealing with indirect effects of biofuels

3.47 To control the indirect effects of biofuels, the use and development of biofuels that use less productive agricultural land needs to be encouraged. One currently proposed option is to provide extra incentives/credits to second-generation biofuels which are generally more land-efficient. However, given that some first generation biofuels have low productive land requirements and that the potential for further generations of biofuels exists, a more technology-neutral, goals-based approach would be preferable. Regarding indirect effects, this means linking incentives to their key determinant: *the amount of productive land used*. There are a number of ways this could be achieved, including:

- **incentives varying by land-efficiency**. If biofuels are incentivised based on their direct life-cycle CO_2 emissions, a "risk premium" could be added to this life-cycle value to reflect indirect effects. This premium would vary depending on the amount of productive land the biofuel requires (for example, if the biofuel was produced from waste, the premium would be zero as no extra land would be used). The scale of the premium could therefore be determined in proportion to the estimated indirect impact of different biofuels on land-use change and the consequent loss of carbon stocks. Many bodies including the US Environmental Protection Agency are currently developing estimates of the indirect effects of biofuels. However, due to large uncertainties in modelling indirect effects, establishing robust estimates that can be used in a regulatory context is a major challenge; and
- **a minimum land-use standard**. This could work as a minimum standard on a biofuel's "CO_2 saving per hectare" or "final fuel energy per hectare". This approach would mean that the least land-efficient biofuels would not comply with the required minimum standard. However, it would not provide incentives to produce more land-efficient biofuels above the standard. Deciding and agreeing on the appropriate level of the standard would also be difficult.

3.48 Whilst both these systems are imperfect, it is important to provide a market signal that only highly land-efficient biofuels should be produced in the long term (whilst ensuring this is not achieved through large increases in fertiliser use which increase emissions of nitrous oxide – a very powerful greenhouse gas). As a precursor to any policy instrument that encourages land-efficiency, a robust metric that can be used to measure the land-efficiency of a given biofuel needs to be developed. The DfT should therefore develop a measurement methodology to be used within the carbon and sustainability reporting framework under the RTFO. This work could be carried out in partnership with the Global Bioenergy Partnership (GBEP)[22] with the aim of establishing an internationally agreed metric.

Recommendation 10: The Department for Transport should lead on developing an agreed EU methodology for measuring the land-efficiency of a biofuel, and consider how this might be reflected in policy options within the Renewable Transport Fuel Obligation and EU targets.

[22] www.globalbioenergy.org.

General measures to reduce deforestation and land-use change

3.49 To complement specific measures on biofuels to improve sustainability, it is also imperative that comprehensive global polices to protect environmentally valuable land continue to be developed. In particular, carbon and biodiversity benefits need to be fully reflected in the value of forests and wetlands. There are a number of ways that environmentally valuable land could be better protected (although none are without their difficulties), such as:

- providing **incentives to land-owners** to prevent damaging land-use change through emissions-trading schemes. For example, under the Clean Development Mechanism, land-owners can be given credits for afforestation and reforestation, and, in the future, it may also be possible to earn credits for avoided deforestation.[23] In practice, a comprehensive scheme such as this will be challenging to deliver because of issues in monitoring and enforcement of land-use change;[24]
- encouraging **stronger local action** to restrict environmentally damaging land-use change around the world. This can be encouraged through global partnerships,[25] through trade agreements, or by rewarding countries with emissions credits if they reduce their deforestation CO_2 emissions below a certain level;[24] and
- **sustainability standards on all uses of biomass** such as that used for food and cosmetics as well as for heat and power. These standards could preclude the use of biomass that has been grown from converted forest. Implementing such standards for biofuels could help set a precedent for expansion to other uses of biomass. Initiatives such as the Round-Table on Sustainable Palm Oil are working towards standards but comprehensive and enforceable standards may not be realised for some time.

3.50 In time, such global land-use policies may reduce the need for specific measures on biofuels' sustainability. However, they are all challenging to implement and enforce comprehensively. Consequently, global policies that adequately guard against environmentally damaging land-use change are many years from being realised. International agreement will be critical in developing any comprehensive policies to prevent environmentally damaging land-use change, and the UK should continue to push for this in international fora such as the United Nations Framework Convention on Climate Change (UNFCCC). As long as such policies are absent or limited in coverage, specific measures to encourage land-efficient biofuels will be needed.

Recommendation 11: Policies to prevent environmentally damaging land-use change around the world should continue to be developed as a matter of urgency alongside specific measures to reduce the land-use impacts of biofuels. The Department for Environment, Food and Rural Affairs should continue to make this a priority in international negotiations such as in the United Nations Framework Convention on Climate Change (UNFCCC).

[23] Large amounts of carbon could be cost-effectively sequestered through forest restoration (*Stern Review on the Economics of Climate Change*, 2007).

[24] These issues will be investigated in the Eliasch Review, which is due to report in Summer 2008.

[25] The UK has allocated £50 million for a Congo forest conservation initiative from the international element of the Environmental Transformation Fund. The goal of this Congo Basin initiative is to prevent the destruction of the Congo Basin Forest whilst safeguarding the livelihoods of 50 million people. The UK has also launched a joint taskforce with Brazil, South Africa and Mozambique to promote the development of a sustainable regional biofuels industry in Southern Africa.

Assessing the sustainability impacts of fuels is a key challenge

3.51 As the previous paragraphs indicate, a fundamental challenge for fuels is that of developing robust methodologies for assessing indirect and wider environmental impacts along with appropriate verification approaches. This is likely to remain an important research challenge for years to come, and, in the interim, practical surrogates for these complex assessments will need to be adopted. Chapter 5 discusses further this research and development challenge.

AN EFFECTIVE AND FAIR GLOBAL MARKET FOR FUELS

3.52 A large proportion of transport fuel is traded internationally and this is likely to increase as some countries begin to deplete their domestic reserves of oil. Moreover, alternative fuels such as biofuels will need to be, at least in part, sourced from other countries where they can be produced more efficiently. The implication of this is clear – if the market for fuels is global then effective policies also need to be global.

Aligning global fuels policies

3.53 The UK and the EU should push for aligned fuels policies across the world (and particularly in the developed world where fuel demand is higher) for two key reasons:

- **avoiding "shuffling"**. Supply of transport fuels is dominated by multi-national companies, who have flexibility over where they supply their fuels. Therefore, if some countries and regions have more stringent polices on the carbon intensity of fuels than others, there is scope for fuel companies to divert their low-carbon fuels to sell in countries with stringent regulation and divert their high-carbon fuels elsewhere, negating the potential positive effect of regulation. In this way, "shuffling" could significantly limit the effectiveness of the 10 per cent by 2020 FQD target.[26] With globally-aligned fuels policies, there would be no incentive for this; and
- **ensuring the global level of ambition is sustainable**. As a result of land (and water) constraints, the global capacity to produce biofuels is limited. Thus, if some countries mandate high volumes of biofuels, this reduces the amount of biofuels other countries can consume sustainably. A key concern is that the high volumes of biofuels the US is mandating will limit the scope for sustainable consumption of biofuels in the rest of the world. National and regional targets affecting biofuels need to be set such that the overall level of demand is sustainable.

Globally-aligned fuels policies would also provide a better investment framework for fuel companies – allowing them better to exploit economies of scale.

3.54 The Fuel Quality Directive provides a framework for EU-wide alignment on the level of ambition for fuels policy, proposing fuel suppliers reduce the carbon-intensity of the fuels they sell by 10 per cent by 2020. Notably, California has also adopted the same target for its Low Carbon Fuel Standard. This level of ambition may imply unsustainable volumes of biofuels, especially if other countries and states adopt it.

[26] The European Union consumes 18 per cent of total oil demand and the UK consumes just 2 per cent (BP Statistical Review of World Energy).

Internationally agreed carbon and sustainability reporting for all fuels is vital

3.55 A key condition in ensuring a sustainable global market for fuels is an internationally agreed regime for measuring and monitoring life-cycle CO_2 emissions and sustainability of all fuels. Without this, it will be impossible to differentiate fairly between fuels with different life-cycle CO_2 emissions and sustainability impacts, thus distorting trade. The UK has developed a carbon and sustainability reporting methodology for biofuels for the RTFO[7] and the EU is working towards an agreed methodology for the FQD and RED targets. The US and many other countries are also developing methodologies. Global coordination of this work is needed to avoid a "patchwork" of conflicting methodologies that distort trade and increase unnecessary regulatory burdens on those trying to navigate different systems. The Global Bioenergy Partnership (GBEP), launched by the G8 + 5,[27] is one organisation working to develop a harmonised methodology to be used by all policy makers in all countries. Ideally, a standard methodology should be agreed with the World Trade Organisation (WTO).

Reducing barriers to trade

3.56 Many of the least costly and lowest-carbon biofuels are from developing countries where growing conditions are often better and labour costs are lower. Thus, encouraging more trade in biofuels will allow more efficient carbon reduction, helping to meet the FQD carbon reduction target at lower cost and, since the imported fuel will often offer higher carbon savings per litre, with lower volumes of biofuels. This should reduce the sustainability risks around the FQD target.

3.57 Concern over the sustainability of biofuels produced in some developing countries may create pressure to restrict trade from these areas. However, restricting trade and forcing more European biofuel production may simply displace food production to the very same developing countries. In this way, trade barriers are unlikely to improve overall sustainability and may even reduce it by forcing biofuels production where this is less carbon-efficient, increasing the volumes required to meet carbon goals. One possible way of improving sustainability is to offer supplier countries reduced trade barriers in return for more stringent land-use policies.[28]

3.58 At present the tariffs on biofuels imported from outside the EU are high – in particular the tariffs on ethanol are very high, typically representing over 20-30 per cent of the value of the fuel.[29] The UK Government should push for reductions in these tariffs in negotiations with the European Commission and at the WTO.

Recommendation 12: Establishing a global market for biofuels is very important in ensuring fuels are decarbonised effectively and efficiently. This Review recommends that the UK Government continue to work internationally on developing a sustainable global market for fuels. In particular by:

- encouraging convergence of global policies on fuels;
- working towards an internationally agreed carbon and sustainability reporting methodology; and
- reducing barriers to trade in biofuels.

[27] The G8 + 5 includes Brazil, China, India, Mexico, and South Africa along with the G8 countries.
[28] *Biofuels: What a Biopact between North and South could achieve*, Matthews, J., Energy Policy, 2007.
[29] DEFRA, 2007.

ENABLING EFFECTIVE EXPANSION OF LOW-CARBON FUELS

3.59 To expand low-carbon fuels and fully realise their benefits, complementary measures to enable their use will be needed. This section identifies two fuels where enabling measures may be needed: biofuels and electricity.

Enabling higher blends of biofuels to be used in cars

The current vehicle stock is not compatible with higher biofuel blends

3.60 In time, provided challenges around the sustainability of biofuels can be addressed, blends of biofuels in the fuel mix exceeding 10 per cent may be desirable. The RED target of 10 per cent biofuels by energy content by 2020 implies biofuel blend levels of 11-15 per cent by volume based on current biofuels (and, as discussed earlier, the FQD target could imply even higher blends of biofuels). At present, vehicles are not generally designed or warranted to run on biofuel blends above 5 per cent by volume. Some existing vehicles may be compatible with 10 per cent by volume blends, but others could not run on these levels without causing damage. Therefore, either vehicles or biofuels need to change to allow blends above 5-10 per cent. There are three potential ways to meet to this challenge:

- modify the general car fleet so that it can take moderate blends of biofuels above 10 per cent by energy or higher;
- increase the number of cars that can run on high blends of biofuels (e.g. flex- fuel vehicles capable of running on up to 85 per cent bioethanol); and/or
- develop biofuels that can be used in blends of above 10 per cent in the existing car fleet.

3.61 To assess which (or what combination) of these measures is most appropriate, it is important to develop an understanding of their relative cost-effectiveness. This could then inform EU decisions on future vehicle and fuel specifications.

Recommendation 13: The European Commission should conduct a study to assess the cost-effectiveness of different measures to enable blends of biofuels of 10 per cent or greater by energy content – reporting before 2010 – and use this to inform any future decisions on vehicle and fuel specifications.

Making the most of electricity as a transport fuel: a "smarter" grid

The CO_2 benefits of electric cars depend on the time of day they are charged

3.62 The King Review Part I identified plug-in hybrids and electric cars as major options for decarbonising road transport, particularly over the medium to long term. The CO_2 emissions from using electricity as a fuel are highly dependent on what time of day the car is charged at – under the current grid mix, charging in the "off-peak" period is more carbon efficient as there is more spare capacity at these times. Therefore, to realise the full carbon benefits of electric-powered cars, measures to encourage charging in the "off-peak" period could play an important role. Such measures could also help spread the electricity demand more evenly over the day, reducing the need for excess generation capacity.

3.63 One potential measure to help achieve this is "time of day" pricing facilitated by smart-metering. Fast and "on-street" charging points could also make the use of electric-powered cars more attractive and carbon-efficient. These opportunities should be considered alongside policies the Department for Business, Enterprise and Regulatory Reform (BERR) is already developing on smart-metering in the home.[30] The development of eco-towns could also offer an opportunity for demonstration of electric vehicle infrastructure (the Government aims to develop ten eco-towns, composed of low-carbon and zero-carbon homes, by 2020).

3.64 Towards 2050, the increasing use of electric vehicles could have major impacts on the level and time profile of electricity demand, with implications for infrastructure. Some scenario planning in this area would help inform any action that might be needed in response to increased use of electricity as a transport fuel.

Recommendation 14: Options to facilitate the efficient use of electric vehicles (such as smart-metering, time-of-day pricing and fast charging points) should be considered alongside existing work by the Department for Business, Enterprise and Regulatory Reform (BERR) on smart-metering in the home and the Government's eco-towns initiative. In addition, BERR, the Department for Transport and the power industry should include the impact of electric vehicles on the electricity grid in relevant scenario planning.

CONCLUSION

3.65 Designing policies to decarbonise transport fuels is a major challenge. Policies must be efficient – ensuring carbon is reduced cost effectively. To reduce carbon at least cost, it is important that policy allows flexibility and incentives for the full range of potential routes to decarbonising fuels. Moreover, policies must be consistent with reducing carbon from road transport and the economy as a whole. Widening the RTFO to cater for more fuels should be considered along with, in the longer term, the potential to include transport fuel suppliers in the EU ETS. Developing a global market for fuels will also be an important step in allowing cost-effective carbon reduction.

3.66 Sustainability is also a major challenge for policy. Biofuels with low environmental impacts could represent a significant part of the fuel mix in the future. However, in the short term, it is important that EU and global targets do not cause biofuels to expand too quickly. Policies must help to drive development of biofuels with very low sustainability impacts, limiting both direct and indirect effects. The development of internationally agreed sustainability standards is a vital part of this, along with general measures to prevent environmentally damaging land-use change.

[30] Energy Billing and Metering – A Consultation on Policies Presented in the Energy White Paper, Department for Business, Enterprise, and Regulatory Reform, August 2007.

4 Consumer choices

INTRODUCTION

4.1 The King Review Part I set out how we, as consumers – through our choices of what to drive, how to drive and when to drive – can make a significant contribution towards an immediate reduction in CO_2 emissions from road transport. Part I estimated that CO_2 savings of 10-15 per cent could come from consumer choices over the next 5-10 years, without compromising our comfort or convenience.

4.2 Consumers can make a difference through:

- **choosing cars**, both in selecting the type of vehicle and the particular model within any vehicle class (e.g. supermini or family car). Simply choosing the most fuel-efficient vehicle within a market segment can reduce a driver's CO_2 emissions by 25 per cent. Selecting a diesel engine of comparable performance to a petrol model can reduce CO_2 emissions by around 15 per cent (although diesel produces higher levels of NO_X and particulates). If consumers are willing to downsize their vehicles potential savings are even greater; and
- **using cars**, by getting the most out of vehicles through smarter driving and choices. More efficient driving techniques such as driving at an appropriate speed, not over-revving, ensuring tyres are correctly inflated, removing roof racks and reducing unnecessary weight can reduce a driver's CO_2 emissions by up to 15 per cent. There is also scope for marginal reductions in CO_2 emissions through making fewer short journeys or using alternative forms of transport.

4.3 Such changes would offer immediate benefits both to the environment and to consumers through lower fuel costs. As discussed in Chapter 2, they would also strengthen market signals to manufacturers about the demand for new low-carbon technologies, helping to pull carbon-saving technologies through to market.

4.4 There is potential to reduce CO_2 emissions in all segments of the car market. In the UK, hatchbacks are by far the most popular vehicle type, with over 1.2 million new purchases in 2006. Sports cars and SUVs sell in much smaller numbers but have much higher emission levels. Fleet vehicles, which include rental, car leasing and personal company cars, are also important. The fleet market accounted for 56 per cent of UK new car registrations in 2006, totalling approximately 1.3 million new registrations. Vans make up over 12 per cent of the stock of fleet vehicles, where many of the smart choices, such as choosing a lower-CO_2 vehicle and driving in a more efficient way, also apply.

KEY POLICY CHALLENGES

4.5 Although there is significant potential to achieve CO_2 savings from consumer choices in the immediate future, realising this is challenging for a number of reasons. The dominant reason is that, in the area of personal transport, there is still a wide gap between people's attitudes towards the environment and their actions through their choice of vehicle and the way they drive. Consumers continue to discount heavily fuel efficiency savings, so potential future fuel savings from choosing a more efficient vehicle are not fully reflected in purchase decisions. As consumers benefit from greater vehicle efficiency in the future, there is a risk that they will choose to buy larger vehicles and drive more, negating some of the benefits of improved vehicle efficiency.

Demand for road travel will increase over time

4.6 Demand for motoring is strongly linked to economic growth. As the economy continues to grow and incomes rise, people are likely to want to increase their spending on motoring. The Eddington Transport Study projected a 28 per cent increase in vehicle kilometres between 2003 and 2025, driven by increasing household incomes and a rising population.[1] In the context of growing demand, emissions reductions are therefore unlikely to be achieved through overall reductions in distance travelled.

4.7 People choose to use their cars for many reasons including necessity, convenience, personal safety, comfort and enjoyment. Improving public transport can make this a more attractive option and must play a key role in reducing emissions from transport. People may also be able to make fewer short journeys, or to walk or cycle, rather than taking the car. However, we must assume that, at least in the medium term, improvements in vehicle, fuel or driving efficiency will be required to achieve emissions reductions on the scale required.

There is a gap between attitudes and actions

4.8 An increasing number of people in the UK express a high level of concern about the environment and the impact of global warming. However, there is currently a large gap between attitudes and actions. The concern people express about the environment is far from fully reflected in their car purchasing decisions and car use. As set out in the King Review Part I people tend to purchase their cars on the basis of upfront price, size, reliability, comfort and safety.[2] Environmental concerns do not figure highly in people's decisions, either in their choice of vehicle or the way in which they drive.

Consumers discount heavily the benefits of fuel economy

4.9 Given that CO_2 emissions depend directly on the amount of fuel consumed, it is encouraging that fuel consumption is identified as one of the most important factors when deciding which car to buy. However, in practice, purchase decisions suggest that consumers take a short-term view when weighing up vehicle purchase costs. Future cost savings from fuel efficiency are discounted heavily at the time of buying a new car,[3] and consumers report that they would require large financial benefits before switching to a smaller car or a car with a smaller engine.[4]

4.10 Consumers often lack easily understandable information on the CO_2 emissions and fuel economy of different vehicles when choosing a new car to purchase, with information expressed as an absolute figure without context often difficult to interpret. This can make it difficult to measure the true running costs of different vehicles. Better information, along with greater awareness of the link between CO_2 emissions and fuel use, and the real cost of running a car, could promote choices that would be better both for the motorist and the environment.

[1] *Eddington Transport Study*, HM Treasury, 2006.
[2] *Car Buyer Research Report*, LowCVP, 2005.
[3] For example see *Demand for Cars and their Attributes*, Cambridge Econometrics, 2008.
[4] *RAC Report on Motoring 2004*, RAC, 2004.

Consumers may purchase larger vehicles

4.11 As vehicle efficiency continues to improve consumers will benefit through lower fuel consumption. Consumers may respond to this by purchasing larger and more powerful vehicles. They may also choose to drive more. These effects could negate some of the savings achieved through reductions in the CO_2 emissions of vehicles.

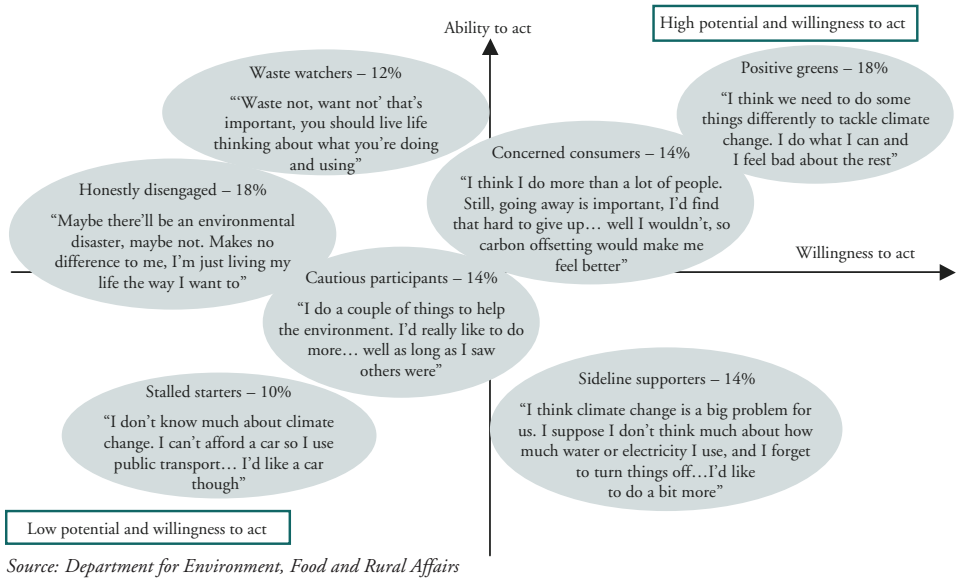
Behaviour needs to be targeted effectively

4.12 People are motivated by different factors, experience different barriers to change, and respond in different ways to policy. An understanding of these attitudes and behaviours is required to identify the potential for people to change their behaviour and the most appropriate policies to encourage this. Box 4.1 shows one approach to segmenting consumers according to their attitudes and behaviours in relation to the environment.

Box 4.1: Segmentation of consumers by attitudes and behaviours

People's different attitudes, motivations and behaviours must be understood when designing policy. The Department for Environment, Food and Rural Affairs has published an environmental segmentation model that aims to segment consumers into seven clusters on this basis, with each cluster including people who share a common set of attitudes, beliefs and behaviours towards the environment.[5] The clusters, which are defined by the ability and willingness of people to take action, are set out in the figure below.

Chart 4.1: Segmentation of consumers by attitudes and behaviours



Source: Department for Environment, Food and Rural Affairs

For the purpose of designing policy these clusters can be grouped into three broad types:

- people who are keen to act and have relatively high potential to do more, where enabling different choices, through overcoming barriers such as a lack of information, and direct engagement are important to promote change;
- people who are willing to act and have the potential to do so, for whom it is important not only to enable new choices, but also for Government to encourage change, for example through fiscal incentives, and to exemplify through its own actions; and
- people who are less likely to make different choices, where regulation can be important.

Segmenting consumers in this way can maximise the effectiveness of policies because it enables interventions to be targeted at overcoming the barriers to change for different groups. In considering how to realise the potential for CO_2 savings from consumer choices, this Review has sought to identify interventions that will enable and encourage change by all individuals.

[5] *A Framework for Pro-Environmental Behaviours*, Department for Environment, Food and Rural Affairs, 2008.

Businesses are also important

4.13 Realising the potential for CO_2 reduction requires action by businesses as well as consumers. Fleet vehicles account for more than half of new vehicles registered each year in the UK. While the profile of fleet models tends to differ little from private car purchases, largely because second-hand car values underpin both sets of buying decisions, businesses can benefit from operating greener fleets and promoting more efficient driving. Fleet operators may be particularly well placed to adopt new technologies because they can benefit from economies of scale in procurement and maintenance. Businesses can also reduce work-related journeys by taking advantage of opportunities for teleworking and teleconferencing and encouraging staff to travel to work using alternatives to the car.

Overcoming these challenges

4.14 Overcoming these challenges to realise the full potential for CO_2 reduction requires action by government, industry and consumers. There have been welcome signs of change in recent years and a number of positive steps have been taken:

- **government** – the "ACT ON CO_2" campaign was launched in 2007 to promote information on driving in a more efficient way and choosing low emission vehicles. Fiscal measures, such as linking vehicle excise duty (VED) and company car tax (CCT) to CO_2 emissions, have been introduced to incentivise more efficient vehicles. Steps have been taken to realise the potential of sustainable procurement and to pilot measures to promote sustainable travel;
- **local authorities** – some local authorities have introduced measures that incentivise more efficient vehicles or the use of alternative forms of transport, while sustainable travel is a greater focus of local transport planning;
- **industry** – car manufacturers are increasingly emphasising their environmental credentials and bringing out "green" models, and voluntary CO_2 labels have been rolled out for new cars. More generally, many businesses have sought to reduce fleet emissions and cut down on work-related journeys; and
- **consumers** – there are positive signs that consumer preferences are slowly beginning to change, with a recent decline in the popularity of some overtly high emission vehicles.

4.15 While progress has been made, realising the full potential from consumer choices requires the concern people express about the environment to be fully reflected in their decisions. This will require action by government, industry and consumers. Better information, incentives and, in some cases, regulation all have a role in changing consumer behaviour. The following section sets out ways in which more of the potential for CO_2 savings from consumer choices could be realised, outlines a number of existing interventions, and makes a series of recommendations for further change.

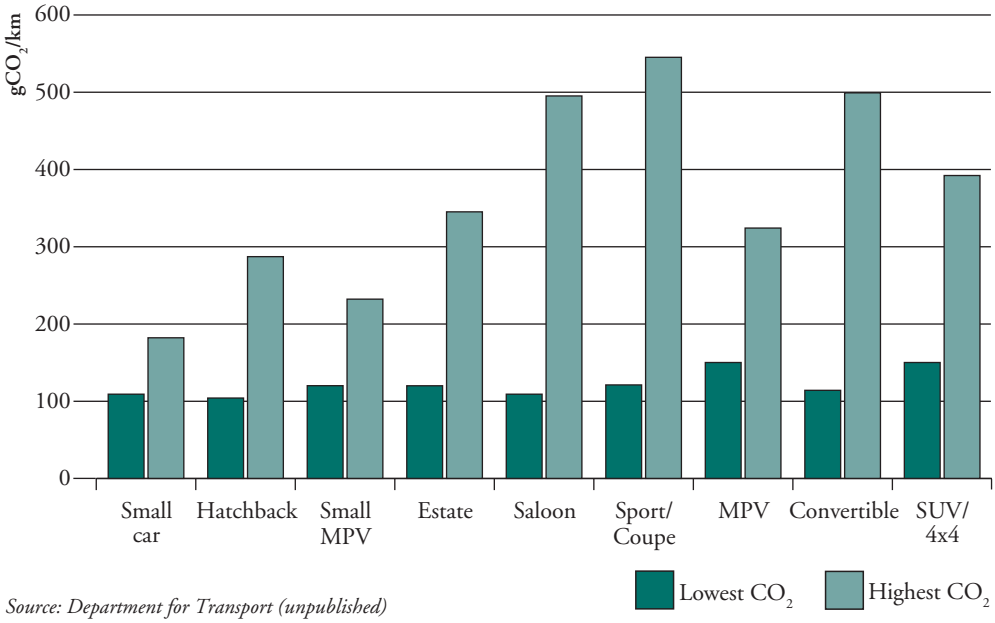
POLICY MEASURES

Choosing cars

4.16 There is a discrepancy between the attitudes people currently express about the environment and their actions through their choice of vehicle. By making different choices, both in selecting the type of vehicle and the particular model within any vehicle class, people can benefit both themselves and the environment. Simply choosing the lowest emission vehicle in a given class can reduce a driver's CO_2 emissions by up to a quarter – as Chart 4.2 shows, there is a significant

range of emissions within all types of vehicle and it is possible to choose a relatively low emission vehicle in any class. If people are prepared to purchase smaller vehicles that still meet their needs, potential savings are even greater.

Chart 4.2: Range of emissions by vehicle class in 2006



Source: Department for Transport (unpublished)

4.17 As discussed in Chapter 2, regulation of vehicle manufacturers can reduce the CO_2 emissions of the average vehicle. The European Commission has proposed regulating for a 130g/km tailpipe emissions target to be reached in Europe by 2012. This would reduce the emissions of like-for-like vehicles through prompting vehicle manufacturers to bring new technologies to market. However, because targets will be utility weighted (as discussed in Chapter 2, this means that each manufacturer will be assigned an individual target based on the size of the average vehicle they currently sell), it will not directly encourage consumers to choose best in class or downsize.

Demand side measures are required

4.18 There is therefore a complementary role for demand side measures to enable and encourage consumers to make decisions that benefit both themselves and the environment and, by stimulating demand, to encourage manufacturers to bring low emission vehicles to market ahead of the legislative requirement. Consumers should be provided with better information to enhance their understanding of the link between CO_2 emissions, fuel use and the real costs of running a car, backed up by strong signals from government, including financial incentives (such as graduating VED by CO_2 emissions) to promote different choices.

Recommendation 15: Government should strengthen demand side policy measures to enable and encourage consumers to choose best in class or downsize. A package of measures is required to deliver change. Consumers should be provided with clear and easy to understand information on the running costs and emissions of different vehicles to support their purchase decisions. This must be backed up by strong and consistent price signals from Government to encourage people to choose the vehicle with the lowest CO_2 emissions that will meet their needs.

Car labels in showrooms

4.19 Information received at the car dealership can be crucial in determining people's choice of vehicle. In order to provide better, standardised information on the CO_2 emissions and fuel economy of cars at the dealership, colour-coded fuel efficiency labels were introduced in 2005 under a voluntary agreement by car manufacturers. The label directly reflects the bandings for VED, displaying the carbon emissions, estimated annual fuel cost and annual VED charge, along with information on the fuel consumption of the vehicle. Early evidence suggests that the labels can be effective in influencing the choice of vehicle of some purchasers. A survey of people who had recently bought or were about to buy a new car found that nearly half of people remembered seeing the label when prompted, and about two thirds of these said that it was important in their choice of vehicle.[6]

4.20 The Review welcomes the introduction of the fuel economy label and believes that coverage should be extended. Labels are currently only displayed on new cars, and because the label is voluntary, around a third of new vehicles sold do not display the label. Coverage would be increased by making display of the label mandatory, as is the case with similar vehicle labels in a number of European countries including Belgium, Denmark, the Netherlands and Portugal.[7] Coverage would also increase if the label were extended to second-hand cars, which account for about three quarters of cars bought each year. While this may not be practical for vehicles sold through private sales, the label could be extended to cars registered from March 2001 (for which the required information on CO_2 emissions is available) that are sold through dealerships. Furthermore, once the required information on CO_2 emissions is published for all new vans, the label could also be displayed on new and second-hand vans, helping to promote greener fleets.

4.21 As well as increasing coverage, the impact of the label must be maximised. The label should be prominently displayed and sales personnel must be adequately trained in understanding and using the label. Furthermore, the information given on the label must be easily understandable and useful for the consumer. At present, the label displays information on the CO_2 emissions and fuel consumption of the vehicle. However, information expressed as an absolute figure without context can be difficult to interpret. Providing comparative information on how emissions and fuel economy relate to other vehicles in the class would aid comparison and enable buyers to make more informed choices – the World Energy Council notes that relative comparison methods on labels are preferable.[8] Comparative information is already included on labels in a number of other countries – labels in the US illustrate how the fuel efficiency of the vehicle relates to others in its class on a bar scale, while labels in a number of European countries display relative rather than absolute information on emissions. Furthermore, it would be helpful to give prominent information on the fuel cost savings that could result from choosing a more efficient vehicle.

[6] LowCVP survey.

[7] *Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars*, Smokers, R. et al., 2006.

[8] *Energy Efficiency Policies around the World: Review and Evaluation*, World Energy Council, 2008.

Recommendation 16: The Review welcomes the introduction of the fuel economy labels to inform consumer purchase decisions. To increase their impact the Department for Transport should:

- extend the labels beyond new cars to cover second-hand cars registered from March 2001 that are sold through dealerships;
- extend the labels to cover new and second-hand vans once the required information on CO_2 emissions is published for all new vans;
- make display of the labels compulsory on all vehicles in the range of the scheme; and
- include comparative information on CO_2 emissions and fuel economy on the label, through providing comparative figures on the class average or best in class vehicle, and by giving prominent information on the fuel cost savings that would result from choosing a more efficient vehicle, in addition to the absolute figures that are currently presented.

Colour-coded tax discs

4.22 To increase understanding among the wider public of how their decisions impact on the environment, the Review believes that it would be helpful for tax discs to be colour-coded so that they reflect the CO_2 emissions of the vehicle. This should be based on the VED bands, but for simplicity could use a traffic light approach, with different coloured discs for vehicles with relatively low emissions (e.g. vehicles in bands A and B, with emissions of 120g/km or less), average emissions (e.g. vehicles in bands C to E, with emissions of 121-185g/km) and relatively high emissions (e.g. those in VED bands F and G, with emissions of 186g/km or more).

4.23 Colour-coded tax discs would reinforce the link between vehicle model, CO_2 emissions and fuel use, by enabling people to see how CO_2 emissions vary both between and within vehicle class. As well as increasing visibility, this could improve people's understanding of how emissions vary between vehicles, promoting the message that it is possible to choose a lower emission vehicle that meets their needs, which could feed through into public opinion, social norms and buying behaviour. They could also increase the value people (and businesses) place on low emission vehicles if they derive benefit from being seen to drive a vehicle with low emissions, further stimulating the market for such vehicles and pulling new technologies through to market. Furthermore, colour-coded tax discs would provide information on the CO_2 emissions of second-hand vehicles purchased through private sales that would not be covered by the proposed extensions to car labelling.

4.24 Colour-coded tax discs would also have a number of potentially useful further applications. They could be used by local authorities or businesses wishing to introduce CO_2-based incentives. For example, the discs could be used to enforce free or dedicated parking for low emission vehicles, such as the Manchester Green Badge Parking scheme (see Box 4.4), while a number of German cities have introduced "environmental zones", with vehicles having to display a green sticker to enter the central area of the city. They could also be used by retailers wishing to provide dedicated parking bays close to store for low emission vehicles.

Recommendation 17: Colour-coded tax discs should be introduced by the Driver and Vehicle Licensing Agency for cars registered from March 2001 that reflect the CO_2 emissions of the vehicle. The discs should be based on the vehicle excise duty bands, for example using a traffic light approach with different coloured discs for vehicles with lower, average and higher emissions.

Vehicle advertising

4.25 Advertising can have a significant influence on people's choice of vehicle, and the motor industry spends a considerable sum of money advertising new cars in the UK.[9] While there has been an increase in the number of lower emission vehicles being marketed on the basis of their green credentials, higher emission vehicles, such as MPVs and 4x4s, are disproportionately represented in the advertising undertaken.[10]

4.26 Existing UK regulation requires that information on CO_2 emissions and fuel economy is given equal prominence to other information on vehicle specification, performance or price in advertisements. However, there is no consistency across advertisements in terms of the format of this information or the prominence it is given. Furthermore, the regulation only applies to advertising with significant textual content, excluding advertising that is primarily graphical such as many street advertisements.

4.27 Providing consumers with clear and easy to understand information on the fuel economy and CO_2 emissions of vehicles advertised would enable people to make more informed purchase decisions. The Review therefore believes that more exacting requirements should be placed on vehicle advertisements. The European Parliament has also backed stronger regulation of vehicle advertising, supporting a proposal that 20 per cent of advertising space should be devoted to information on CO_2 emissions. Any new regulation introduced should ensure that information on CO_2 emissions and fuel economy is provided in a prominent and consistent way in advertisements across all media. Provision of comparative information would also be beneficial. In setting precise requirements, consideration must be given to what consumers would find most helpful.

Recommendation 18: Regulation of vehicle advertising should be strengthened so that information on CO_2 emissions and fuel economy is presented in a more prominent and consistent form in advertisements across all media. This should include a requirement to display comparative information on emissions relative to other vehicles in class. The Review recommends that the Department for Transport should establish an advisory group including the advertising industry and the Committee of Advertising Practice to gather and review available evidence and recommend the regulatory standards that consumers would find most helpful, reporting with specific proposals by the end of 2008.

Information campaigns

4.28 Appropriately targeted information campaigns can be effective in changing consumer behaviour. The Department for Transport (DfT) launched a campaign in March 2007 under the cross-Government "ACT ON CO_2" banner to highlight how buying a more efficient car can reduce carbon emissions as well as fuel bills. The campaign also promotes information on driving in a more efficient way (see Box 4.2 for more information on the campaign).

[9] For example, see *De-marketing the car*, Wright, C. and Egan, J., 2000, on the impact of advertising on vehicle choice.

[10] Friends of the Earth Survey, 2007.

Box 4.2: "ACT ON CO_2" campaign

A Government campaign to promote smarter driving and the purchase of more fuel-efficient vehicles was launched under the cross-Government "ACT ON CO_2" brand in March 2007. Initially the campaign focused on promoting more efficient driving through advertising in the national press, on television and radio, online and through outdoor posters. This advertising encouraged drivers to consider the way they treat their engine when driving and directed them to the campaign website (www.dft.gov.uk/actonco2) which offered further smarter driving tips.

The second phase of the campaign, launched in July 2007, focused on encouraging consumers to purchase more fuel-efficient cars. It highlighted that buying a car with a more fuel-efficient engine reduces fuel bills as well as CO_2 emissions, and directed consumers to the "ACT ON CO_2" website where the "Best on CO_2 Rankings", developed in association with *What Car?*, lists the top ten new cars with the lowest CO_2 emissions in their class.

4.29 The Review welcomes the launch of the campaign and supports Government continuing to promote messages on choosing more fuel-efficient vehicles and smarter driving under the "ACT ON CO_2" banner. To increase the effectiveness of the campaign, the Review believes that its visibility should be increased by expanding beyond the initial advertising campaign and website. For example, greater impact might be achieved through providing information to people face-to-face in shopping centres, supermarkets, petrol stations, servicing centres and car showrooms. Drivers may be particularly receptive to messages on smarter driving when taking their vehicle for a service or MOT, when a prompt about checking vehicle condition, including tyre pressures, could be particularly appropriate.

4.30 At present the campaign's messages emphasise how consumers, through their individual decisions and behaviours, can reduce carbon emissions and benefit the environment. This message is likely to resonate particularly well with people who are keen to reduce their carbon footprint but require information on how to do so. To extend the reach of the campaign to people who would be willing, but are less likely, to make different choices, the Review believes that placing a greater emphasis on the financial benefits of changing behaviour would be beneficial.

Recommendation 19: The Department for Transport should develop and reinforce the "ACT ON CO_2" campaign. To enhance the effectiveness of the campaign:

- in addition to the current advertising campaign, the campaign's messages should be promoted to people face-to-face, for example through providing information in shopping centres, supermarkets and petrol stations. Drivers may be particularly receptive to messages on smarter driving when taking their vehicle for a service or MOT; and
- a greater focus should be placed on emphasising the financial benefits to consumers, as this is likely to influence the behaviour of a wider range of people.

Information in schools

4.31 Promoting an understanding among children of all ages in schools about how driving contributes to CO_2 emissions, and how different choices can reduce this impact, provides an opportunity to target future drivers and to harness "pester power". Experience from schools taking part in the Eco-Schools programme demonstrates how this can be effective, and programmes such as the Biotechnology and Biological Sciences Research Council's "mini beasts" initiative, which aims to spark the interest of children in biology by using creepy crawlies, show the type of learning opportunities that can be effective in engaging children. All schools should look to promote children's understanding of sustainability issues, including the impact of vehicle emissions on climate change and how this can be reduced. Incorporating examples into appropriate areas of the curriculum and ensuring that teachers have access to suitable teaching materials can facilitate this.[11] Coordination of the development and provision of appropriate teaching materials could be taken forward by bodies such as the Science Council and the Association for Science Education, and through the National Science Learning Centre.

Recommendation 20: The Department for Children, Schools and Families should ensure that children of all ages have the opportunity in school to learn how driving contributes to CO_2 emissions and how different choices can reduce its impact.

Financial incentives

4.32 Information must be backed up by strong and consistent price signals from government to encourage people to choose the vehicle with the lowest CO_2 emissions that will meet their needs. Incentives can be particularly important in influencing the decisions of people who would be willing to make different choices but require encouragement in order to do so. Incentives also have an important role in stimulating the market for lower emission vehicles.

4.33 Fiscal incentives can be crucial in determining the choices people make, both in terms of the vehicle they buy and its subsequent use. A range of different fiscal incentives can be used to influence consumer behaviour:

- point of purchase incentives – such as purchase taxes/rebates and capital allowances. Upfront incentives can be particularly effective in influencing people's choice of vehicle given that consumers tend to discount heavily future costs;
- circulation incentives – such as an annual registration tax (e.g. vehicle excise duty (VED)) and taxes imposed on fleet vehicles (e.g. company car tax (CCT)). These can influence people's choice of vehicle by affecting the ongoing running costs of different cars, as well as having a significant impact on the residual value of cars in the second-hand market; and
- vehicle use incentives – incentives that change the cost of driving, such as fuel taxes, mileage allowances and road pricing, can influence people's travel decisions, for example by encouraging people to choose an alternative form of transport or to share a car with others. They can also affect people's choice of vehicle by increasing the cost of running larger and less efficient cars.

[11] A range of teaching materials on sustainability issues are available at www.teachernet.gov.uk/sustainableschools.

4.34 Using a balanced package of incentives is desirable to provide a clear message to consumers and reduce the risk of unexpected side effects. The UK Government already uses a number of fiscal instruments to promote its environmental objectives. VED for new cars has been based on the CO_2 emissions of the vehicle since March 2001. In 2008-09 VED will be £400 for the highest emission vehicles while the lowest emission vehicles will pay a zero rate. CCT was also reformed in April 2002 to be based on CO_2 emissions. In addition, fuel duty provides an incentive to choose a more efficient vehicle, whilst also promoting more efficient driving. Evidence shows that these incentives can be effective in changing behaviour. For example, a survey by HM Revenue & Customs found that CO_2-based CCT led to 60 per cent of company car buyers choosing a lower CO_2 vehicle.[12]

4.35 Box 4.3 provides some examples of fiscal measures used in other countries that can influence people's choice of vehicle and its subsequent use.

Box 4.3: Examples of the use of fiscal incentives in other countries

Purchase taxes are levied on the purchase of new cars in a number of European countries. Where these are based on engine size or CO_2 emissions, such as in the Netherlands, they can incentivise consumers to choose smaller or more efficient vehicles. France introduced a new tax/refund system for new car purchases in January 2008. Vehicles in the lowest bands (those emitting 130g/km or less) receive a rebate of up to €1,000, while vehicles in higher bands (those emitting 161g/km or more) face a tax of up to €2,600 for the highest emitters.

Evidence from the Netherlands suggests that purchase taxes can be highly effective in influencing consumer behaviour. In 2002, a year long rebate of €500-€1,000 on the purchase of lower emission vehicles led to their market share increasing from 9.8 per cent the previous year to 19.3 per cent in the year of the incentive.[13]

Circulation taxes are widely levied across Europe, although the size and nature of the tax imposed varies considerably. Many countries vary the charge according to engine size, fuel consumption or, increasingly, CO_2 emissions. Ireland has announced that its circulation tax will change from being based on engine size to CO_2 emissions from July 2008, with the annual cost ranging from €100 for vehicles emitting 120g/km or less up to €2,000 for vehicles emitting 226g/km or more.

The most common **vehicle use incentive** imposed is taxation on fuel, although rates vary and a number of countries levy lower rates for alternative or cleaner fuels. Road tolls are imposed in a number of European countries, including France, Germany, Italy and Spain.

Local schemes

4.36 A number of local measures have been introduced, both in the UK and abroad, that incentivise low emission vehicles and/or influence people's choices of how and when to travel. These include free or reduced-rate parking and local congestion charges. Some examples are set out in Box 4.4.

[12] *Report on the Evaluation of the Company Car Tax Reform: Stage 2*, HM Revenue & Customs, 2006.

[13] *Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars*, Smokers, R. et al., 2006.

Box 4.4: Examples of local measures to promote more efficient vehicles

London Congestion Charge

London introduced a Congestion Charge in February 2003, with vehicles entering the charging zone required to pay £5 a day (subsequently increased to £8). Alternative fuel and electric vehicles are exempt from paying the charge. The charge was estimated to have prompted an initial 16 per cent reduction in CO_2 emissions within the charging zone.[14]

From October 2008, a graduated charge will be introduced based on vehicle CO_2 emissions, with the objective of encouraging people to travel in lower emission vehicles. Vehicles that emit less than 120g/km and meet the Euro IV standard will be exempt from paying the charge, while the charge for vehicles with high emissions (those emitting more than 225g/km) will be increased from £8 to £25.

CO_2-based parking permits in Richmond

The cost of parking permits in the London Borough of Richmond has been based on vehicle CO_2 emissions since April 2007. The cost of permits for vehicles in VED bands A-C was reduced from the previous level while the cost for vehicles in bands D-G was increased. A permit for a first vehicle in band A is now free while the cost for the first vehicle in band G is £300.

Manchester Green Badge Parking Permit

The Manchester Green Badge Parking Permit was launched in July 2007. It offers a 25 per cent discount on NCP car parks within Manchester for badge holders. Badges are available for vehicles that emit less than 120g/km. Similar parking incentives have also been launched in a number of other cities. For example, Westminster City Council has introduced free parking for electric vehicles.

4.37 The Review welcomes local authorities introducing such measures where they are appropriately designed and introduced with the objective of reducing CO_2 emissions. Appropriate incentives can reinforce the link between fuel economy, CO_2 emissions and running costs for consumers, and play an important role in stimulating the market for low emission vehicles in the shorter term. For example, the popularity of electric vehicles in London may in part have been driven by their exemption from the London Congestion Charge. Local incentives can also encourage people to choose alternatives to the car or to travel at different times. Introducing colour-coded tax discs (see Recommendation 17) would help local authorities wishing to bring in such measures in the future.

[14] *Central London Congestion Charging – Impacts Monitoring Fifth Annual Report*, Transport for London, 2007.

Recommendation 21: The Review welcomes local authorities introducing measures that incentivise consumers to choose lower emission vehicles where they are appropriately designed and are introduced with the objective of reducing CO_2. Where introduced, measures should:

- be based on carbon emissions rather than technology, equally incentivising all vehicles with equivalent CO_2 emissions;
- be maintained for a reasonable period of time to give consumers confidence in opting for lower emission vehicles. However, they should also be reviewed over time as the CO_2 emissions of the average car decline; and
- not encourage people to drive more, by making it easier or cheaper to do so, leading to increased congestion and higher CO_2 emissions.

Public sector procurement

4.38 The Sustainable Procurement Task Force report *Procuring the Future* noted the contribution that sustainable procurement can make to furthering environmental objectives.[15] The public sector fleet is estimated to include approximately 200,000 light duty vehicles and 100,000 heavy duty vehicles, and around 75,000 light duty vehicles are purchased or leased by the public sector each year.[16] In procuring these vehicles, public sector organisations should look to choose the most efficient vehicles that meet their needs. This can make a direct contribution to reducing CO_2 emissions, as well as exemplifying lower-carbon choices to businesses and consumers. As discussed in Chapter 5, public sector procurement can also play a role in bringing new technologies to market, and DfT has announced up to £50 million of funding to promote procurement of low-carbon vehicles by public sector bodies.

4.39 While procurement of more efficient vehicles can benefit public sector bodies themselves through lower running costs, there may be a number of barriers to sustainable procurement including short-term cost pressures and uncertainty over how to estimate whole life costs.[17] In order to realise the benefits from procuring lower carbon vehicles, value for money should not be equated with lowest upfront cost and full consideration must be given to the longer-term savings that result from procuring more efficient vehicles.

4.40 To promote the procurement of more efficient vehicles, Government has set an average fleet car procurement target of 130g/km by 2010-11 for new cars purchased by central government and used for administrative operations.[18] While the Review welcomes this target, procurement by central government departments and agencies represents only a small proportion of vehicles procured by the public sector as a whole. Significantly greater benefits could be achieved if the average emissions of vehicles procured across the whole of the public sector could be similarly reduced.

[15] *Procuring the Future – The Sustainable Procurement Task Force National Action Plan*, Department for Environment, Food and Rural Affairs, 2006.
[16] *Low Carbon Vehicle Procurement programme – discussion paper*, Department for Transport, 2007.
[17] *Sustainable procurement in central government*, National Audit Office, 2005.
[18] *Energy White Paper: Meeting the Energy Challenge*, Department for Trade and Industry, 2007.

Recommendation 22: All public bodies should look to match central government by setting an ambition to reduce the average emissions of new vehicles procured for administrative purposes to 130g/km by 2010-11.

Private sector procurement

4.41 Private sector organisations should also look to reduce CO_2 emissions from their vehicle fleets. Greener fleet policies can benefit not only the environment but also the company, with the Energy Saving Trust estimating that using more efficient vehicles can save a business operating 100 vehicles up to £90,000 a year.[19] Fleet buyers may be particularly well placed to purchase lower CO_2 vehicles – environmental responsibility is closely aligned with corporate responsibility and fleet operators can benefit from economies of scale in procurement and maintenance. However, a perception of greater upfront cost is often a barrier. To promote greener fleets, the Energy Saving Trust runs a fleet advice programme, funded by DfT, which offers free bespoke consultancy to larger fleet operators and provides information on greener procurement for smaller operators. Carbon emissions reporting, advocated by the recent CBI report *Climate Change: Everyone's Business*, could sharpen the incentives for businesses to consider the potential for greening their fleets if it included company vehicles.[20] Recommendations in this Review that would improve information on the running costs of vehicles, such as extending the coverage of the fuel economy label, could also facilitate a transition towards greener fleets.

Using cars – smarter driving

4.42 Smarter driving, often also referred to as eco-driving, involves driving in a more efficient way in order to improve fuel economy, which reduces CO_2 emissions and saves drivers money. Examples of smarter driving techniques include driving at an appropriate speed, not over-revving, ensuring tyres are correctly inflated, removing roof racks and reducing unnecessary weight. The King Review Part I estimated that efficient driving techniques could reduce CO_2 emissions from cars by 15 per cent.

4.43 As technology develops, some of these driving efficiencies are likely to become electronically automated in vehicles. However, driver behaviour will also be important, particularly in the shorter term. To realise the potential for CO_2 savings, drivers must be aware of how they can change their driving behaviours to increase fuel economy. While many aspects of efficient driving mirror how people are taught when they first learn to drive, people often slip into different habits. Information provision, practical training and technology all have a role in enabling and encouraging people to drive in a more efficient way.

Improving information

4.44 As set out above, the "ACT ON CO_2" campaign promotes information on smarter driving through a national advertising campaign and campaign website. The Review believes that Government should continue to promote messages on smarter driving as part of this campaign, and has made a number of recommendations on how its effectiveness could be enhanced (see Recommendation 19).

[19] *Behind the Wheel: Understanding the business case for greener company car fleets*, Energy Saving Trust, 2007.
[20] *Climate change: Everyone's business*, CBI, 2007.

Practical training

4.45 Practical training in efficient driving can embed positive driving behaviours. A study by the Driving Standards Agency (DSA) found that two hours of eco-driving training led to an 8.5 per cent improvement in the fuel efficiency of car drivers. This would reduce a driver's annual fuel bill by around £100.[21]

4.46 The driving test provides a unique opportunity for embedding smarter driving behaviours in new drivers. A number of countries, including the Netherlands and Finland, already incorporate smarter driving into the practical test, and this has been shown to make a difference in the way people drive. The Review welcomes steps taken by the DSA to incorporate smarter driving into the UK driving test. Questions on smarter driving were introduced into the theory test in September 2007. Smarter driving will also be made part of the practical test from September 2008.

4.47 Existing drivers also need to be targeted in order to reduce carbon emissions in the short term. Some driving schools in the UK already offer short courses in smarter driving techniques, but only a very small proportion of all drivers undertake these. Evidence suggests that many individuals would be willing to pay to attend a training course provided that they could recoup the cost through lower fuel costs.[22] Businesses may be particularly willing to fund such training if it reduces the cost of operating their vehicle fleets. However, there are a number of barriers to uptake, including a lack of awareness that such training is available and of the benefits that it can bring through lower fuel costs.

Recommendation 23: The Department for Transport should promote the benefits of undertaking training in more efficient driving techniques, both to individuals and businesses, as part of the "ACT ON CO_2" campaign, and should provide accreditation to suitable training programmes.

4.48 Driving efficiently is also important in vans, particularly as they typically carry more weight than cars. Studies have shown that training can achieve significant increases in fuel economy. For example, the provision of training to 91 van drivers employed by Hamburger Wasserwerke in Germany led to a 5.8 per cent reduction in fuel consumption over the following six months.[23] In the UK, the Safe and Fuel Efficient Driving programme, funded by DfT, provides a one-day course for drivers of vans as well as larger vehicles. The Energy Saving Trust's fleet advice programme also provides information on efficient driving to fleet drivers.

Speed

4.49 The speed at which people drive has an important bearing on CO_2 emissions. More than half of drivers exceed the motorway speed limit and nearly a fifth travel at over 80 mph.[24] Such speeds are significantly above the optimum for fuel economy. For example, a medium-sized petrol car typically produces around 15 per cent more CO_2 per kilometre at 80 mph than at 70 mph.[25] As well as reducing carbon emissions, driving at a lower speed can also improve traffic flow and reduce congestion, as demonstrated by the experience of Active Traffic Management on the M25 and M42.

[21] RAC estimate.
[22] Research by the Energy Saving Trust found that 36 per cent of drivers would be willing to pay £50 for a two-hour lesson if the cost could be recouped through fuel savings within eight months.
[23] *Ecodriving: Smart, efficient driving techniques*, Energy Saving Trust, 2005.
[24] *Road Statistics 2006: Traffic, Speeds and Congestion*, Department for Transport, 2007.
[25] Based on information from the National Atmospheric Emissions Inventory.

In-vehicle technology

4.50 A number of in-vehicle technologies are available that can promote a more efficient driving style through providing information and advice to the driver. Some examples of the technology already available are set out in Box 4.5.

Box 4.5: Examples of technologies that can promote smarter driving

In-car fuel economy meters

Instruments are available that can display real-time information on fuel consumption, driving time and travel costs to drivers within the vehicle. These can help to improve the time and money perception of drivers. A study reported by Cousins (2006) found that the instruments were both popular and effective in changing behaviour, with 20 per cent of participants reporting that they purchased a more fuel-efficient car as a result.[26]

Gear shift indicators

Changing gear at the optimal time can reduce revs and therefore fuel consumption. Gear shift indicators are instruments in the vehicle that give information to the driver on the optimal point to change gear. A study by Smokers et al. (2006) estimated that gear shift indicators could typically reduce fuel consumption by 1.5 per cent given the propensity of drivers to act on the information given.[27] Gear shift indicators are also relatively cheap to fit to new cars – Cousins (2006) suggests that £5 is a suitable target volume price.

Tyre pressure monitoring systems

Evidence suggests that the majority of vehicles are driven with underinflated tyres. This reduces fuel economy as well as increasing tyre wear and reducing safety. Tyre pressure monitoring systems inform the driver when a tyre requires inflating. Stock (2005), cited by Smokers et al. (2006), estimated that the introduction of tyre pressure monitoring systems could reduce fuel consumption by 2.5 per cent if the driver acts on the information provided by the system.

4.51 This technology is already incorporated into some vehicles on the market. For example, Toyota, Nissan and BMW already install fuel economy meters in some of their vehicles. However, greater environmental benefits could be achieved if appropriate technology were introduced to all new passenger vehicles. Some technology, such as gear shift indicators, can also be retrofitted to existing vehicles at relatively low cost. This would bring further benefits, as technology would take well over a decade to reach all cars if only fitted to new vehicles. Appropriate incentives can promote this. For example in the Netherlands, a VAT exemption for in-vehicle devices to promote smarter driving led to the penetration of such devices increasing from 13 to 33 per cent over a four year period, and it is estimated that around half of the devices would not have been purchased without the tax exemption.[28]

4.52 Given that appropriate technology could lead to improvements in driver efficiency, the Review believes that there is a strong case for introducing regulation at the European level to ensure that this technology is fitted to all new vehicles sold in the EU. However, before mandating particular technology, it is necessary to understand which technologies would be most appropriate to fit to vehicles. If technology is to be effective it needs to be simple for the driver to understand and easy to act upon. New technology must also not compromise road safety by distracting drivers.

[26] *New dashboard instruments inform CO_2 policies for new vehicles,* Cousins, S. in *LowCVP 'Low Carbon Road Transport Challenge': Proposals to reduce road transport CO_2 emissions in the UK to help mitigate climate change*, LowCVP, 2006.

[27] *Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars*, Smokers, R. et al., 2006.

[28] *Improving the energy efficiency of road transport: the case of eco-driving in the Netherlands*, Harmsen, R. et al., 2007.

Recommendation 24: The Department for Transport should work with the European Commission and manufacturers to ensure an evidence base is developed on what dashboard technology could be safely incorporated into vehicles to promote more efficient driving. The European Commission should then regulate to make appropriate technology mandatory in all new vehicles sold in the EU. The Government should also promote and incentivise the retrofitting of technology to existing vehicles.

Using cars – smarter choices

4.53 CO_2 emissions from road transport can be reduced if people choose less carbon intensive alternatives to the car such as public transport, walking and cycling (often referred to as "smarter choices"). As well as reducing CO_2, changing travel behaviour can benefit the individual through time and cost savings, and have positive impacts on congestion, air quality and public health. Research commissioned by DfT found that smarter choices measures have the potential to reduce traffic volumes by 11 per cent over ten years, with a cut of about one fifth in urban peak-hour traffic.[29]

4.54 For people to choose lower-carbon alternatives to the car, change must be convenient and alternative options attractive to the individual. Effective promotion is essential to improve awareness. It must also be recognised that for some journeys a car will be the most convenient option. For these journeys, car sharing and car clubs can play a role, while combining trips and timing journeys to avoid congestion can also make a difference.

Switching to lower-carbon alternatives

4.55 Over half of car journeys are less than five miles and nearly a quarter are less than two.[30] These journeys make a disproportionate contribution to CO_2 emissions because fuel consumption is higher when the engine is not yet working at full efficiency. There is scope for some of these journeys to switch to alternative forms of transport such as public transport, walking and cycling if these are realistic and attractive alternatives. Convenience, speed, safety and cost are all important in determining how people choose to travel. Investment in bus and rail services is important in enabling people to make low carbon choices, and public transport must be properly integrated and coordinated. Walking and cycling routes and facilities must also be improved.

4.56 Effective marketing is needed to promote information about low-carbon alternatives and overcome negative perceptions. Marketing campaigns have proven highly effective in changing travel behaviour, particularly when coupled with service improvements. For example, a direct marketing campaign in Perth led to a 63 per cent increase in bus passengers over three years.[31] Personalised journey planners can also promote use of public transport. Transport Direct (www.transportdirect.info) is a UK-wide online journey planner that enables people to compare making a journey by car or public transport in terms of time, cost and CO_2 emissions.

[29] *Making Smarter Choices Work*, Department for Transport, 2004.
[30] *National Travel Survey: 2006*, Department for Transport, 2006.
[31] *Making Smarter Choices Work*, Department for Transport, 2004.

4.57 People will not switch away from cars if there is perceived to be a high cost to doing so. Over the past 30 years the real cost of motoring has fallen by 10 per cent while bus and rail fares have increased by more than 50 per cent.[32] Public transport must be competitively priced in relation to car travel to encourage people to change their behaviour. Furthermore, people tend to underestimate the cost of motoring relative to other forms of transport – the average motorist underestimates their car running costs by around a factor of two.[33] Measures that make the marginal cost of journeys more transparent can help to overcome this. Pay-as-you-go insurance and, in the future, road pricing can improve a consumer's perception of the true marginal cost of travelling by car by replacing a large fixed cost with a small cost for each additional kilometre driven.

Role of local authorities

4.58 Local authorities are responsible for most public transport outside of London. It is therefore important that they make sustainable travel a priority. At present this is not always the case. A study published in 2007 found that, while all Local Transport Plans made some reference to smarter choices, only 27 per cent made significant reference.[34] To ensure that the full potential for smarter choices is realised, sustainable travel needs to be made a priority by all local authorities in their local transport strategy.

Recommendation 25: All local authorities should ensure that smarter choices are a priority in their local transport strategy.

Travel planning

4.59 Travel planning has proved to be particularly effective in promoting smarter choices. Travel planning can incorporate a number of measures that encourage people to switch to lower-carbon alternatives, including increasing the provision and attractiveness of alternatives to the car, providing better information and offering incentives for switching. It can be implemented in a variety of situations, including in a residential, school and workplace context. Box 4.6 sets out the benefits that effective travel planning can bring and what the Government is already doing to promote it.

Box 4.6: The benefits of travel planning and existing Government initiatives

Personal travel planning – Sustainable Travel Towns

Personal travel planning is a targeted marketing technique that encourages more sustainable travel choices by providing travel advice and information to people face-to-face based on an understanding of their personal trip patterns. Evidence from personal travel planning projects in the UK suggests that it typically reduces car travel by 12 per cent among those targeted.[35] It is also highly cost effective, typically costing between £20 and £38 per household targeted, with economies of scale potentially reducing the cost for larger scale implementation.

In 2004, DfT awarded £10 million over five years to three towns – Darlington, Peterborough and Worcester – to pilot personal travel planning among a large proportion of their population. Darlington aims to offer travel advice to all of its 40,000 households over three years. Initial results have been very positive, with a 15 per cent increase in walking and a 65 per cent increase in cycling between 2004 and 2006, while car trips fell by 9 per cent over the same period.[36]

[32] Office for National Statistics.

[33] *RAC Report on Motoring 2004,* RAC, 2004.

[34] *Review of the Take-Up of Smarter Choices in Local Transport Plans*, Department for Transport, 2007. A Local Transport Plan sets out the local authority's local transport strategies and policies along with an implementation programme.

[35] *Making Personal Travel Planning Work: Research Report*, Department for Transport, 2007.

[36] *Towards a Sustainable Transport System*, Department for Transport, 2007.

Box 4.6: The benefits of travel planning and existing Government initiatives *(continued)*

School travel planning – School Travel Initiative

School travel planning aims to reduce the number of children travelling to school by car. Measures can include encouraging walking and cycling (e.g. through setting up walking buses and providing cycle training), improving school bus services and making changes to the area around the school. Travel plans typically reduce car use for the majority of schools, and a well-developed programme of travel planning across several schools can reduce school run traffic by 8-15 per cent.[37]

The Government launched the Travelling to School Initiative in 2003, with £7.5 million per annum made available to fund a network of local travel advisers to work with schools in developing travel plans. There is a target for all schools in England to have a travel plan in place by 2010. Funding has also been made available for complementary measures. For example, in 2007, grants were awarded to 3,200 primary schools to set up walking buses or other walking initiatives.

Workplace travel planning – National Business Travel Network

Workplace travel plans typically include measures to support walking, cycling, the use of public transport and car sharing. Promotion and incentives, as well as the management of workplace parking, often reinforce these measures. Workplace travel plans can reduce the number of employees commuting to work by car by an average of 15 to 20 per cent.[38]

To promote workplace travel planning in the private sector, DfT set up the National Business Travel Network (NBTN) in 2007. The NBTN is a business-to-business network that enables companies to share best practice and promote the rationale for workplace travel planning through regular meetings and workshops. In its first year the NBTN has attracted about 250 members.

Personal travel planning

4.60 There is considerable evidence that personal travel planning can be effective in promoting sustainable travel, and initial findings from the Sustainable Travel Town pilots are highly positive (see Box 4.6). The benefits in larger, more congested urban areas are potentially even greater. The Review therefore believes that there is a strong case for rolling out personal travel planning more widely across the UK. This will require a sustainable source of funding, rather than the grant funding from central government or other bodies that has been used to fund most existing schemes. Given the range of benefits that travel planning can bring, including lower congestion, higher public transport patronage and public health benefits, this could draw on a range of sources including local authorities, public transport operators, primary care trusts, developers and local businesses.

Recommendation 26: The Department for Transport should work with local authorities to establish how a widespread implementation of personal travel planning could be sustainably funded. To strengthen the evidence base on the benefits of personal travel planning in different settings, the Department for Transport should consider establishing new pilots to assess the effectiveness of personal travel planning in larger urban areas.

[37] *Making Smarter Choices Work*, Department for Transport, 2004.
[38] *Smarter Choices – Changing the Way We Travel*, Cairns, S. et al., 2004.

Workplace travel planning

4.61 Workplace travel plans are a proven means of promoting more sustainable travel through reducing commuting by car (as discussed in Box 4.6). The Review welcomes the establishment of the National Business Travel Network to promote the development of travel planning across large organisations in the private sector. All large private sector organisations should look to introduce workplace travel plans, which can benefit their employees and boost the organisation's environmental credentials.

4.62 As well as targeting the private sector, public organisations should also ensure that they have their own travel plans in place, both to provide a lead and to make a direct contribution to reducing CO_2 emissions. Where travel plans have been implemented in the public sector they have been shown to be effective. For example, Buckinghamshire County Council reduced the proportion of its employees driving to work from 71 per cent to 49 per cent between 1998 and 2003 through negotiating discounts on public transport, improving cycling facilities and setting up a car sharing scheme.[39] Travel plans can also benefit the organisation directly, for example through reducing the need for employee parking. However, despite these benefits, many public sector organisations do not yet have a travel plan in place.

Recommendation 27: All large public sector bodies should have a workplace travel plan in place by 2010.

Reducing the need for trips

4.63 As well as switching to lower-carbon transport, there may be scope at the margin for some people to reduce the number of journeys they make. Advances in technology provide a number of opportunities – teleworking and teleconferencing both reduce the need for trips associated with work, while home shopping can reduce the need to drive to the supermarket. People can also reduce the CO_2 emissions associated with necessary trips by combining trips where possible.

4.64 The design of towns and cities also impacts on people's need to travel. The planning system should ensure that, where possible, new developments are located to facilitate sustainable travel choices, with sustainable travel made a priority in Local Development Frameworks. Similar provision should be made in the location of new schools, hospitals and government buildings. The Government's commitment to increase housing supply by at least 240,000 homes a year by 2016 provides an important opportunity, while the Government's proposed eco-town developments should look to minimise people's need to travel by car where possible.

More efficient use of cars

4.65 Carbon emissions can be reduced if people make more efficient use of their vehicles. Over the last two decades, average car occupancy has declined while the proportion of single occupancy car trips has increased. Car sharing, where two or more people travel together, for example to work or school, reduces CO_2 emissions and congestion through taking cars off the road as well as benefiting the individual by saving time and money.

4.66 Choosing the best route and avoiding congestion brings similar benefits. The Eddington Transport Study concluded that almost 30 per cent of travel time in major urban areas is spent at speeds below 5 mph. In-car and roadside technology, and in the future road pricing, can enable people to make more informed choices over where and when to travel.

[39] *Making Smarter Choices Work*, Department for Transport, 2004.

Car clubs

4.67 Car clubs provide members with access to a fleet of vehicles in their neighbourhood for short-term hire. This allows people to use a car when this is their best option without incurring the fixed costs of individual car ownership. Car clubs are well established in a number of countries including Switzerland, Germany and the US. In the UK they are still at an early stage of development, although there has been rapid growth in recent years, particularly in London, with more than 36,000 members having access to over 1,300 cars.[40] While car clubs promote access to cars for some, a reduction in car ownership and use of more efficient vehicles means that overall they lead to net carbon savings. Evidence from the UK and abroad suggests that for each car club vehicle about five private cars are taken off the road, and that people giving up cars when joining a car club reduce their mileage by about two-thirds. The typical car club vehicle is also significantly more efficient than the average car registered in the UK, and car clubs should look to choose the lowest emission vehicles that meet their needs.

4.68 While car clubs are set to continue expanding in the UK, government may be able to facilitate more rapid penetration, particularly outside larger conurbations. Promotion of car clubs by central government could increase awareness and enable people to make informed decisions over whether car clubs could be appropriate for them personally. Local authorities can also take a number of steps to support car clubs in their area. For example, in Bristol, the local authority provided a start-up grant, designated parking bays and publicity to support the set-up of a car club in the area.

Recommendation 28: Local authorities should consider promoting car clubs in their area as part of their local transport strategy. The Department for Transport should also raise awareness of car clubs so that people can make informed decisions over whether they are an appropriate option for them.

CONCLUSION

4.69 There is significant scope for reducing CO_2 emissions from road transport through consumer choices. However, harnessing this potential poses a considerable challenge. In particular, it requires people's expressed concern about the environment to be fully reflected in their decisions. This will require better information to enable people to make more informed decisions, and the provision of incentives to encourage change. As set out in this chapter, government, industry and consumers all have an important role to play in meeting this challenge.

[40] www.carplus.org.uk.

5 Research and development

INTRODUCTION

5.1 Delivering the technology required to decarbonise road transport is a global challenge, and to meet its own carbon commitments, the UK must adopt the best solutions from around the world. However, the UK is also well placed to develop solutions itself. It has some world-class engineering capability, and its high technology firms are leading the way in several aspects of low-carbon car innovation, including in some of the technologies required for hybrid and battery powered cars. The UK therefore has an opportunity to position itself in a leading role for the low-carbon future in a number of areas:

- as a supplier of innovative low-carbon solutions in the short to medium term, with the right environment for innovative companies to grow and demonstrate technology and develop international markets;
- in key areas of long-term research, for example novel energy storage and plant breeding for biofuels; and
- as a location for inward investment by high technology companies and an attractive location for scientists and engineers working with world leading research groups in key areas of science and technology.

5.2 This chapter sets out a range of recommendations to help the UK seize this opportunity.

5.3 The technological progress necessary to achieve CO_2 reductions in the UK car fleet, and ultimately to almost completely decarbonise cars, represents a considerable research and development (R&D) challenge and opportunity requiring engagement of the UK's best innovators and researchers.

KEY POLICY CHALLENGES

Realising the potential for CO_2 reduction set out in Part I

5.4 The King Review Part I set out the short-term technological challenge: widespread adoption of technologies that are already close to market that could reduce average new car emissions by 30 per cent through incremental improvements (for example, through weight reduction, aerodynamic improvements, regenerative braking, improved drivetrain technologies and further improvements to internal combustion engine efficiency). Previous chapters have made recommendations on how to meet the challenge of accelerating the progress of existing technologies "from shelf to showroom" through both supply side measures (Chapter 2) and encouraging consumers to demand the best low-carbon technologies (Chapter 4).

5.5 In the short to medium term (10-15 years), to achieve further reductions of the order of 50 per cent, significant technical, cost and infrastructure challenges must be met (alongside continued measures to stimulate the market as explored in Chapters 2 and 4) to bring promising solutions through the innovation and product development cycle to demonstration and into production.

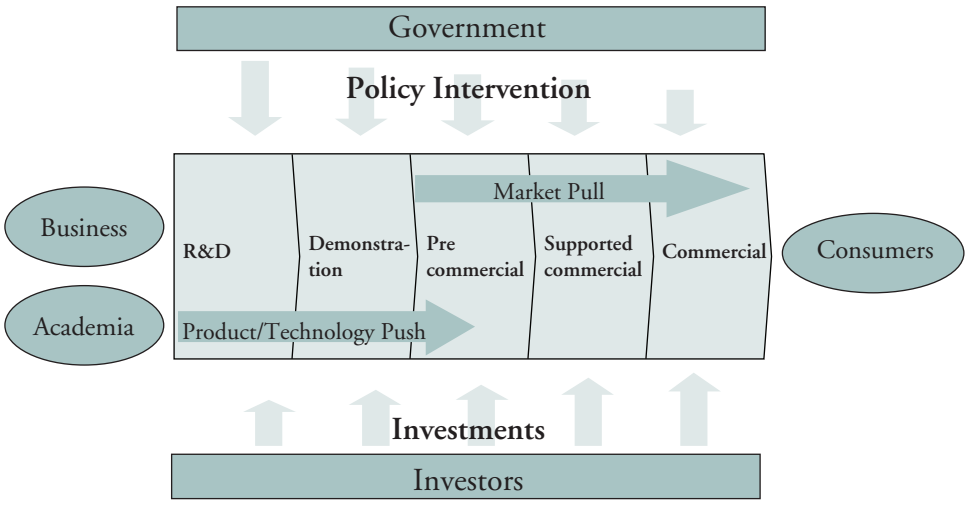
5.6 To deliver the long-term goal of 80-90 per cent reductions in car emissions (essentially decarbonisation of cars), focused fundamental research on a 15-30 year time-frame is needed to address the science challenges. Step change technologies such as novel batteries and other means of energy storage are likely to be needed. These technical challenges are significant, so it is reassuring at this stage that several routes are being explored, and it is important, globally, that all are driven forward: electric vehicles, hydrogen powered vehicles and novel sustainable biofuels. The rewards for success in all three areas are potentially very high because the basic technologies – namely electric systems, batteries, fuel cells and sustainable liquid fuels – could have critical long-term applications well beyond road transport. A number of supporting areas will also require significant research – for example recycling, re-use and resource consumption will all become a more significant proportion of a car's "whole life" emissions.

5.7 Increased personal mobility supports economic growth in emerging and developing economies. The expected rise of car ownership in China and India from just a handful of cars per thousand people to approaching 400 cars per thousand people by 2050[1] makes it particularly important to ensure that these economies are in a position to adopt low-carbon technologies. The current primary focus of car development in India, exemplified by the Tata Nano,[2] is increasing affordability, rather than reducing emissions. There is a critical opportunity for countries with low-carbon technologies to collaborate with India, China and other emerging economies now to deliver low-cost, low-carbon solutions for personal transport. A key challenge for the UK is to maximise the influence of some of our low-carbon automotive technologies to reduce CO_2 and ensure the UK plays a growing role in the new automotive industries and markets that develop.

The innovation process

5.8 Innovation is a complex process. Success relies on the coming together of a variety of players, including suppliers, customers, universities, research and technology organisations and other intermediaries. Successful technologies usually pass through several stages within a development process from basic R&D through to commercial deployment. The process can be influenced by government, investors, academia and business, as progress through the stages is subject to a number of driving (and potentially inhibiting) forces.

Diagram 5.1: The R&D Innovation Chain



[1] *The BRICs and Global Markets: Crude, Cars and Capital*, Goldman Sachs, 2004.
[2] See for example http://www.tatamotors.com/our_world/press_releases.php?ID=340&action=Pull.

The case for government intervention in low-carbon car R&D

5.9 In general, the private sector is best placed to make judgements on the appropriate level of investment in R&D because private firms best understand the markets in which they operate. In the UK the private industrial sector is by far the largest investor in R&D, with most of this investment occurring in the later stages of innovation and in incremental technological development. However, R&D is characterised by a number of barriers that can reduce the incentives for private industry to undertake investment particularly pertinent to the low-carbon car arena:

- **uncertainty** – where there is doubt about which new technologies are likely to be demanded and adopted by consumers, or there is uncertainty about the future policy environment or infrastructure development, such uncertainties can act as a barrier to investment in R&D. Given the inherent risk, private sector firms may require a higher expected rate of return to undertake the investment than can be assured;
- **myopia** – while the benefits of many technological breakthroughs are long term, the private sector expects shorter-term returns on its investment. R&D timescales tend to be relatively long in the automotive field, so smaller firms in particular may suffer from investors' tendency to discount heavily returns from investments that occur too far in the future. Access to capital for research on a long-term basis can be harder to obtain, even in highly profitable industries; and
- **infrastructure requirements** – although it may be possible to introduce some low-carbon transport fuels into the existing infrastructure and vehicle technology, over the longer term key breakthrough low-carbon technologies, such as battery or hydrogen powered vehicles, are likely to require large-scale investment in supporting infrastructure. This investment may well be in the hands of third parties or government. There is therefore likely to be uncertainty over whether the market will deliver the necessary investment without sufficient coordination with government or other infrastructure investors; and

All of these factors are relevant to low-carbon automotive developments at present.

Further barriers to investment

5.10 There are further barriers that may impede R&D investment in future low-carbon transport technologies. One factor preventing the emergence and take up of low-carbon solutions is technology "lock-in" – the dominance of an inferior, high cost technology over a newer technology that could ultimately prove cheaper once experience in producing and using that technology has been gained.

5.11 Replacement of the vehicle stock on the road is also relatively slow (the average car in the UK has a lifespan of 13 years) which determines the time taken for the widespread adoption of new technologies.

5.12 In many ways the last stages of the innovation chain are particularly risky for radical new vehicle technologies, as production must be scaled up and products painstakingly tested before there can be sufficient certainty about whether there will be a market for the technology. This can require heavy investment in production facilities. A car is also a safety-critical product, which once launched tends to be widely dispersed to a large customer base. Problems and product recalls are costly and damaging to a manufacturer's reputation. For these reasons the investment needed at the final stages of development can be particularly high.

5.13 All of these factors, when taken together, can mean that the market will not necessarily attract as much investment in low-carbon automotive R&D as would be desired in order to drive forward the medium- and long-term decarbonisation of cars. There is therefore a case for Government intervention to support an increase in the level of R&D undertaken. Such support could take a number of possible forms – from subsidising research inputs, for example through funding for researchers, to increasing the rewards for successful outputs, for example through R&D tax credits or guaranteeing a market for successful technologies. The rest of this chapter makes recommendations on areas where Government support can make a significant difference.

CURRENT POLICY CONTEXT

Channels of R&D support for business

5.14 This section sets out the current Government support mechanisms for R&D. Support for low-carbon technology R&D in companies is available via a number of routes:

- at the European level, through the EU Framework Programme;
- at the national level, where there are large number of bodies responsible for promoting research into low-carbon technologies and a wide range of different funding streams; and
- at the regional level, through RDA-funded programmes.

5.15 At the European level, the principal funding streams for collaborative research and innovation are through the EU Framework Programme. The programmes aim to strengthen partnerships with teams across Europe to share knowledge, skills and expertise and give access to new networks, markets and contacts. Themes within Framework Programme 6 included sustainable surface transport, which covers road vehicle technologies, underpinned by €670m in funding, and sustainable energy systems, covering biofuels, hydrogen and fuel cells, receiving €890m in funding. Framework Programmes fund specific research projects, as well as networks of excellence. In Framework Programme 7, which runs from 2007 to 2013, €4.16bn will be allocated to transport (all modes), €1.89bn to environmental research and €2.35bn to energy.

UK R&D support

5.16 At the national level there are a large number of bodies responsible for promoting research into low-carbon technology and a wide range of different funding streams. The Technology Strategy Board (TSB) is a business-focused organisation established as an executive body at arm's length from Government in July 2007, and sponsored by the Department for Innovation, Universities and Skills (DIUS). The TSB supports pre-commercial, industrial, collaborative R&D (CRD) and Knowledge Transfer Networks. CRD is designed to assist the industrial and research communities to work together on R&D projects in strategically important areas of science, engineering and technology – from which successful new products, processes and services can emerge. There has been one call for applications dedicated to environmentally friendly transport, and in more recent calls, materials for transport, biofuels production and hydrogen and fuel cells have been included.

5.17 The TSB recently launched the Low Carbon Vehicles Innovation Platform (LCVIP) with the aims of accelerating the market introduction of low-carbon road vehicles and maximising the benefit to UK business, thereby responding to the societal and business challenge posed by the need to reduce transport CO_2 emissions. It brings together and enhances Government support mechanisms for technology development within the context of the LCVIP. Its first activity is a collaborative R&D programme, with £30m of support from the Department for Transport (DfT), the Engineering and Physical Sciences Research Council (EPSRC) and the TSB. It is focused on bringing forward vehicle technologies that could be viable candidates for commercialisation or fleet procurement over the next 5-7 years.

5.18 Government grants for R&D administered by Regional Development Agencies (RDAs) provide finance to individuals and small and medium size enterprises (SMEs) in England to research and develop technologically innovative products and processes. Various different types of projects can be supported through this scheme; from micro projects, through research and development projects to large development that is strategically important for the sector, with funding of up to £500,000.

5.19 The recently formed Energy Technologies Institute[3] (ETI) is currently considering a transportation theme. The ETI intends to focus on funding of "system level" demonstrator programmes. In addition there are a number of other bodies that have funding streams for promoting specific areas of research, including the Environmental Transformation Fund (ETF), the Carbon Trust, and the UK Energy Research Centre (UKERC). There are also Knowledge Transfer Networks (KTNs) dedicated to low-carbon car technologies such as the Low Carbon Vehicle and Fuel Cells KTN. More detail on these is set out in Box 5.1.

5.20 Additional efforts are also being made to promote R&D into low-carbon technology at the regional level. The West Midlands RDA, Advantage West Midlands (AWM), and automotive companies have funded the Premium Automotive Research and Development programme to assist suppliers to enhance the manufacturing and design capabilities of West Midlands supplier companies. This includes projects in the field of hybrid vehicles and lightweight materials, part of a £60m total programme budget spread across 19 projects, of which £33m of funding was from AWM.

R&D tax credits

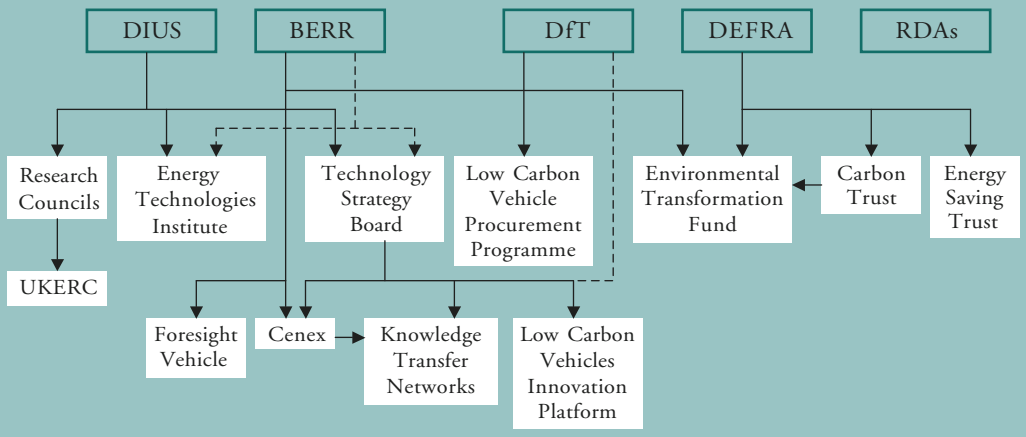
5.21 In addition to the various bodies and funding streams, R&D tax credits are available to encourage companies to invest in R&D. They do so through either reducing the tax bill for a company or providing them with a cash lump sum (the latter is usually for SMEs). All companies spending over £10,000 per annum on R&D can claim a deduction on their taxable profits of 150 per cent of qualifying expenditure for SMEs, or 125 per cent of qualifying expenditure for larger companies. This has resulted in a £250m/year rebate. In Budget 2006 it was announced that companies with up to 500 employees would be able to apply for the higher R&D tax credit, where previously only companies with less than 250 employees could receive this higher credit. A 2005 report conducted by HMRC[4] showed that more than half of respondents thought the credits incentivised additional R&D and many said that they had already had an impact (34 per cent said it had enabled them to take on longer-term projects, 24 per cent that it enabled them to take on riskier projects, and 16 per cent that it had enabled R&D to take place in the UK). A study by the Institute for Fiscal Studies[5] (IFS) has also found that tax credits are an effective way of increasing R&D.

[3] Announced at Budget 2006 and set up by DIUS.

[4] www.hmrc.gov.uk/research.

[5] *Do R&D tax credits work? Evidence from a panel of countries 1979 – 1997*, IFS, 1999.

Box 5.1: UK bodies promoting low-carbon technology R&D



The **Energy Technologies Institute** (ETI) is a new Public Private Partnership commissioning R&D to accelerate the development, demonstration and eventual commercial deployment of a focused portfolio of low-carbon energy solutions which will increase energy efficiency, reduce greenhouse gas emissions and help achieve energy and climate change goals. It has matched Government funding of up to £500m.

The **Environmental Transformation Fund** has been set up by Government to support demonstration and deployment activities in low-carbon technologies from 2008 onwards.

The **Low Carbon Vehicles Innovation Platform** (LCVIP) is a £30m technology competition recently launched by the TSB and DfT, with additional funding contributions from the Engineering and Physical Sciences Research Council (EPSRC). The LCVIP is focused on bringing forward relatively near to market low-carbon vehicle technologies that could be viable for commercialisation or fleet procurement initiatives over the next 5-7 years. Projects must be undertaken in the UK and involve at least two collaborators. It is expected that projects will be industry led, but industry-academic collaborations will also be considered. The scheme will provide up to 50 per cent of eligible costs. The first call for applications has recently closed and results will be disseminated shortly.

The **Carbon Trust** is a private company established by the Government in 2001 with the aim of accelerating the move to a low-carbon economy by working with organisations to reduce carbon emissions and develop commercial low-carbon technologies. It provides funding for the development of commercial low-carbon technologies and also contributes to Research Council funding for early stage research.

Foresight Vehicle is a partner of the Low Carbon Vehicle knowledge transfer network. Foresight Vehicle is run by the Society of Motor Manufacturers and Traders Ltd (SMMT) which aims to drive forward R&D in this sector. It is a collaborative network between government, academia and industry to identify and demonstrate sustainable technologies for road transport. The R&D programme aims to promote technology and stimulate suppliers to develop market driven enabling technologies for motor vehicles. The parties that set up Foresight Vehicle created a Technology Roadmap, which identified five themes reflecting the technology development needs for the next 20 years: engine and powertrain; hybrid, electric and alternatively fuelled vehicles; advanced software, sensors, electronics and telematics; advanced structures and materials; and design and manufacturing process.

Cenex is an industry-led public-private partnership set up with the aim of assisting UK industry to build competitive advantage from the global shift to a low-carbon economy. It supports the Low Carbon Vehicle and Fuel Cells Knowledge Transfer Network and works with SMMT Foresight Vehicle.

The academic research base

5.22 The UK also has a world-class academic research base. A number of Research Councils fund research into low-carbon transport, including the Engineering and Physical Sciences Research Council (EPSRC), which has a Sustainable Urban Transport Environment Programme and leads the Research Council Energy Programme, including biofuels, with the Biotechnology and Biological Sciences Research Council (BBSRC), Economic and Social Research Council (ESRC), Natural Environment Research Council (NERC) and the Science & Technology Facilities Council (STFC). To a lesser extent, the UK Energy Research Centre (UKERC) and the Tyndall Centre also undertake research in this area although they mainly focus on transport behaviour.

Opportunities for UK industry

5.23 The UK has a short- to medium-term interest in the manufacture of internal combustion engines. As this technology evolves, there are major opportunities for the UK in design and manufacture if UK capabilities in both areas can keep up with changing demands.

5.24 UK industry has significant expertise in a range of technologies key to hybrid powertrains such as control systems and electric drivetrains. High quality small- and medium-sized enterprises (such as those listed in Box 5.2) have the opportunity to expand into major international markets in these new and developing areas provided they have the vision and are able to make the investment necessary to exploit this.

Box 5.2: A selection of UK firms with expertise in a range of technologies that are likely to be key for the future

Lotus Engineering – which is collaborating with its parent company on an innovative hybrid system capable of being retrofitted to cars not originally designed as hybrids.

Modec and **Smith Electric Vehicles** – two firms that produce electric delivery vehicles.

Ricardo – a leading provider of technology, product innovation, engineering solutions and strategic consulting to the world's car makers. Recently Ricardo led a consortium comprising QinetiQ and PSA Peugeot Citroen which successfully developed a diesel-hybrid prototype car, the Efficient-C.

Torotrak – a world leader in the design and development of Infinitely Variable Transmission (IVT) systems. Torotrak's principal commercial strategy is to generate royalty income from high-volume manufacture of IVT technology by its licensed customers. In addition, consultancy income is earned from providing expertise to vehicle and transmission manufacturers in the development of IVTs for their specific applications.

Zytec Group – provides engineering solutions to the UK's leading automotive groups and pioneering developers of new electric vehicles. This includes developing advanced powertrain control systems for Continental and supplying electric engines for DaimlerChrysler's Smart EV and Modec's delivery vehicles.

5.25 UK industry, working with government, must be prepared for high value manufacturing opportunities in the areas of the developing low-carbon technologies if the UK is to maintain its position in manufacturing as well as vehicle and system design and innovation.

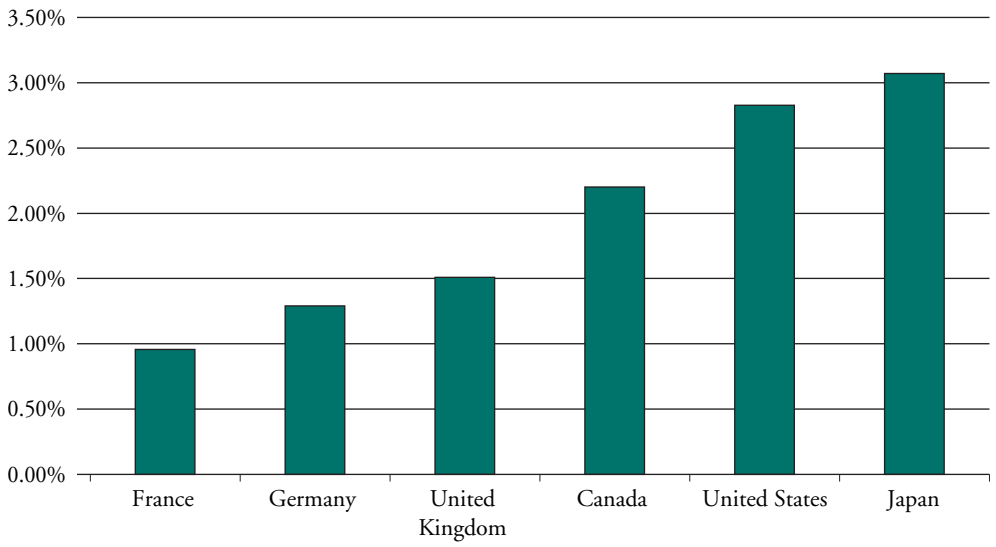
POLICY MEASURES

Delivering innovation

Public funding for R&D

5.26 The Science and Innovation Investment Framework 2004-2014[6] set out the Government's commitment to increase investment in the public science base at least in line with the trend growth rate of the economy over the ten-year period. Recent years have seen a large and very welcome increase in public funding for the research base, and by 2007-08, total UK science spending will be £5.4 billion. This has been critical in establishing the long-term sustainability of the science base.

Chart 5.1: Percentage of public civil R&D budgets spent on non-nuclear and non-fossil fuel extraction energy R&D (2004)



Source: Derived from IEA data (2004)

5.27 However, recent reports from the Confederation of British Industry (CBI)[7] and Engineering Employers' Federation (EEF)[8] have drawn attention to the relatively low public spend in the UK on energy-related R&D as a percentage of GDP when compared with other G7 nations. These comparisons can be misleading, as they include, for example, the nationalised nuclear programmes in some other countries as well as some other areas of energy R&D spend unrelated to reducing emissions. However, if the UK is to take a leading role in low-emissions technology, a strong focus on this area in public R&D funding seems appropriate. Chart 5.1 shows, as a proportion of total public civil R&D, the public spending on energy related R&D excluding nuclear spending. This reflects, as far as possible, the categories of spend that are likely to deliver low-carbon transport technologies[9] although it predates the founding of the ETI. If the UK is to play a leadership role in this critical area, there is a strong case for the Government to give greater priority to low-carbon R&D within overall R&D spending.

[6] *Science & innovation investment framework 2004-2014: next steps*, HM Treasury, 2004.
[7] *Climate Change, everyone's business*, CBI, 2007.
[8] *Delivering the low-carbon economy*, EEF, 2007.
[9] Includes energy efficiency, total CO_2 capture and storage, renewable energy sources, hydrogen and fuel cells, other power and storage technologies, total other technologies/research. Excludes fossil fuels (except carbon capture and storage) and nuclear. IEA data, 2005.

Recommendation 29: The Review welcomes the Government's increased expenditure on R&D in recent years and recommends to Government and independent bodies responsible for public R&D funding that they increase the share of the funding assigned to low-carbon R&D, including low-carbon vehicles.

The landscape of innovation support

5.28 Government support is needed throughout the innovation system from fundamental research and its application in new technology-based solutions to supporting new technologies at the demonstration and pre-commercial stages so that there is sufficient early market demand-pull.

5.29 As outlined in the previous section, a number of organisations have recently been established in this field. An increase in emphasis and effort is welcome to help address the challenges faced. However, with the diversity of organisations now responsible for awarding public R&D funds, there is a danger of duplication of effort, creating confusion among the industrial and research communities and an unnecessary administrative burden.

5.30 As many of these bodies have been established relatively recently, it is difficult to assess the effectiveness of the current landscape. However, it is clear that all bodies, particularly those receiving government funding, need to establish a distinctive role and communicate this clearly to the user communities.

Recommendation 30: The UK organisations conducting and funding R&D should establish and publish clear statements setting out the distinctive roles that they will undertake, to provide clarity at the earliest opportunity.

In addition, the current arrangements as a whole should be evaluated by the Department for Innovation, Universities and Skills and HM Treasury in terms of effectiveness and value for money in advance of the next Government Spending Review.

Bringing low-carbon technology to market

5.31 As noted in Chapter 2, one of the potential barriers to bringing new low-carbon technologies to market is that, until mass production is achieved, combined with effective cost reduction, new low-carbon technologies are likely to be more expensive than established ones. In addition, the supporting infrastructure required (e.g. charging points for batteries) may take time to develop. There are a number of ways in which government can help to overcome these barriers.

5.32 The TSB invests in R&D, building partnerships between business, researchers and government to address major societal challenges and running a wide range of knowledge exchange programmes to help innovation flourish. It is dedicated to promoting technology-enabled innovation across the UK. Its vision is for the UK to be seen as a global leader in innovation and a magnet for technology-intensive companies, where new technology is applied rapidly and effectively to create wealth.

5.33 The TSB, with DfT, has recently launched the Low Carbon Vehicles Innovation Platform (LCVIP). The LCVIP seeks to position the UK's automotive sector to benefit from growing public and private sector demand for lower carbon vehicles. This is a welcome initiative. The first joint competition (with funding of £20m), with DfT, for projects involving near to market technology has been heavily oversubscribed, showing a strong appetite for this opportunity within the UK automotive industry. The TSB believes that much higher funding in this area would provide excellent returns through exploiting more fully the innovative potential of UK companies.

5.34 The TSB and its partners are developing an extended vision for radical vehicle technologies as part of the LCVIP. This phase of the innovation process is often the most difficult, indeed it is sometimes termed "the Valley of Death", particularly where innovative technologies are involved which may be expensive to test or have new infrastructure requirements. The extended vision would provide the possibility of "end-to-end" support, from innovative research or concepts, in academia or from other sources, through to a range of linked experimental fleet demonstration and subsequent public procurement opportunities, along an appropriate timescale. The objective is to provide a "line of sight" from early stage development through to market opportunities. The Review strongly supports this initiative and encourages other Government Departments, RDAs and Development Agencies and other funders and public sector organisations to become involved to provide the funding, demonstration and procurement opportunities that will be needed to make this a success. Clarification of the appropriate application of state aid rules will be an essential early step in the development of this project.

5.35 The Government has also set out a vision for eco-towns – new towns of 5,000-20,000 homes. These towns will be exemplar "green" developments, and will be designed to meet the highest standards of sustainability, including zero carbon technologies and good public transport, as well leading the way in design, facilities and services, jobs, health and community involvement. This appears to offer an excellent opportunity to demonstrate and evaluate new and innovative technologies at the "system level", for example electric cars and their impact on the operation of the infrastructure, including smart metering and grid management. The Review would encourage the new Energy Technologies Institute, with its system demonstration focus, to consider a project of this sort, linked to the LCVIP.

5.36 A LCVIP with a long-term funding commitment, from a range of sources, of between £100m–£200m, linked to high profile demonstration opportunities in the public and private sectors – including one or more "radical vehicle technology" eco-towns – would be a very strong and positive message to the automotive industry here and overseas that the UK was developing a leadership role in low-carbon vehicles.

Recommendation 31: The Technology Strategy Board and its partners should extend the Low Carbon Vehicles Innovation Platform to provide clear demonstration opportunities for new low-carbon vehicle technologies through implementation of experimental fleets linked to future procurement opportunities.

5.37 UK industry had relatively limited involvement within the European Union Framework 6 Programme. Framework 7 (FP7) brings new opportunities, with significant funding. There is an important role for the TSB to play in helping UK companies to bid successfully for EU funds. The Review recommends that the TSB reviews the current support mechanisms for assisting companies in winning EU funds, and looks at whether some of the other TSB activities, such as the Knowledge Transfer Networks, could play a stronger role in this area. The TSB should also examine ways to strengthen UK influence within the FP7 transport programmes.

5.38 The UK is involved in many of these projects, but to a lesser extent than some other countries. For example, low-carbon engine/powertrain development has tended to be led by large mainland European car manufacturers through the EUCAR group, of which the UK is not currently a very active member. The UK holds a 6-8 per cent share of four activities (advanced diesel combustion, heavy diesels, hydrogen fuel cells and internal combustion of hydrogen) in this area, accounting for around €50m of EU funding).

Recommendation 32: The Technology Strategy Board (TSB) should review the current support mechanisms for assisting companies in winning EU funds, and report by the end of 2008 on whether some of the other TSB "products", such as the Knowledge Transfer Networks, could play a stronger role in this area. The TSB should also work to strengthen UK influence within the Framework 7 transport programmes.

Short- to medium-term R&D challenges

5.39 The need for urgent effort in the field of low-carbon car innovation is clear. There are major challenges, for the short, medium and long term, that will need to be addressed by both the academic and industrial research and development communities before very low-carbon cars can become a reality. The King Review's high-level assessment of the potential for CO_2 reduction highlighted the following areas as some of the most important challenges.

Medium-term vehicle batteries and battery management

5.40 Battery technology offers considerable promise and batteries are already used to power niche electric vehicles and in hybrid vehicles. Current batteries offer limited energy density, and there is significant scope for optimising existing battery technologies for automotive applications including improving charging and discharge rates. In the short to medium term, further improvements to the design of Lithium-ion batteries seem likely to come from nanotechnology[10] and more advanced chemistries. Manufacturing, recycling, sustainability and cost issues must also be addressed.

Electric systems for car propulsion

5.41 Most of the "next generation" low-carbon automotive technologies operate within an electric propulsion system, whether in a hybrid vehicle or a fully-electric or fuel cell powered car. Areas of existing UK expertise include control electronics, battery management and integration technologies, and fuel cell developments.

Lightweight materials and components

5.42 Vehicle weight has increased in recent decades as vehicles have become better equipped and safer. Weight reduction in any area initiates a virtuous circle, reducing power requirements and hence the size and weight of the propulsion system, brakes and other components. The application, and in some cases development, of low-cost lightweight materials, with low-energy manufacturing routes, designed for easy recycling or re-use, will be critical. New wear-resistant and low-friction coatings and other technologies will also contribute to weight and power reduction.

[10] *Building better batteries*, Armand, M. and Tarascon, J-M., Nature Vol 45 pp 653 – 657, 2008.

Developing biofuel technology

5.43 For biofuels to represent a high proportion of the fuel mix, substantial developments are needed to increase their sustainability (particularly in terms of land use) and to bring costs down. These developments will require greater integration between fuel suppliers, vehicle manufacturers and the agricultural sector, drawing on a range of disciplines. A recent report on biofuels by the Royal Society[11] identifies a number of key research challenges, including:

- developing feedstocks with increased yield per hectare while reducing negative environmental impacts;
- developing feedstocks which can be grown in more hostile environments;
- development and demonstration of integrated biorefineries; and
- integration of biofuel development with engine development.

5.44 The UK has a strong plant sciences and biotechnology research community which can address these research challenges by developing improved biofuel feedstocks through plant breeding. This is an area where genetic engineering could play a critical role in accelerating development of woody crops with long breeding times. The debate over safe use of genetic engineering for biofuels has distinct features from that for food crops as these crops will not be eaten, although public concerns over influence on the environment and nearby crops will remain. Given the strength of the UK research community in this area, a more positive public attitude to the benefits of genetic engineering could play a significant role in attracting the plant biotechnology/breeding industry back to the UK.

Recommendation 33: The Department for Environment, Food and Rural Affairs should facilitate an informed public debate, by exploring emerging evidence on the risks and benefits of genetically modified plants for non-food applications, in the context of the impact of climate change and wider sustainability issues.

Measuring and monitoring the environmental impacts of biofuels

5.45 Verified and agreed methodologies for defining, measuring and monitoring the environmental impacts of biofuels are necessary to underpin robust and enforceable reporting on the carbon and wider sustainability impacts of biofuels. Research is needed across a range of areas, including impact assessments when biofuels are produced as part of a range of products and the indirect effects of biofuels. Developing systems to monitor changes in land use (for example, through satellite observation technology) is also important. These developments are essential to facilitate and support policies that ensure that we develop and use biofuels and biofuel processing routes that make a real contribution to reducing CO_2 emissions.

Consumer behaviour

5.46 We must improve our understanding of the factors that influence consumer behaviour in order to maximise the potential of new technologies and the demand for them. The Economic and Social Research Council (ESRC) and the Department for Environment Food and Rural Affairs (DEFRA), in consultation with the Scottish Government, the Welsh Assembly Government, the Department of Environment Northern Ireland, the Environment Agency and other potential partners across the UK, have recently consulted on establishing an independent, multidisciplinary, academically based Research Centre on Sustainable Behaviours. It is envisaged that the focus of the Centre would be on the research challenges of informing moves within UK society towards more environmentally sustainable patterns of consumption and ways of living, and of achieving more effective pro-environmental behaviours to help to address the environmental challenges faced by the UK in the wider world. The Review welcomes the establishment of this Centre and encourages it to pick up the low-carbon vehicles agenda at an early stage.

[11] *Sustainable biofuels; prospects and challenges*, The Royal Society, 2008.

CO_2 emissions and road charging

5.47 There are a number of areas that would benefit from a multidisciplinary approach across technology and the social sciences. One example is the feasibility, and acceptability, of the future use of increasingly sophisticated methods of road user charging. This could include establishing whether, in the future, pricing could take account of time, distance, place, occupancy and CO_2 emissions. This would require innovative technologies (for example to measure the actual emissions or car occupancy), acceptability to the wider public of the basis for charging and the need for consumer confidence in secure and accurate billing. The Department for Transport is currently leading a substantial programme of research exploring the feasibility of charging for road use by time, distance and place. This Demonstrations Project will, amongst other things, be examining ways of ensuring trust in the system.

Recommendation 34: The new Research Centre on Sustainable Behaviours should make low-carbon cars an early priority, including the potential for future approaches to road charging, drawing on the Department for Transport's findings.

Recycling, re-use and sustainability

5.48 As the tailpipe emissions from cars reduce, the current figure of approximately 15 per cent of life-cycle emissions being associated with manufacture and disposal will rise sharply. In addition precious metals and other "exotic materials" are likely to be needed to produce novel batteries or to store hydrogen. Recycling of such materials will be critical from both a resource supply and environmental impact viewpoint. Assessing the environmental impact of all types of material – organic and inorganic – and designing in recyclability and low-impact manufacturing and processing routes must be key considerations from the earliest stages in all developments.

Long-term Grand Challenges for Research

5.49 The 2050 goal of decarbonised cars offers some important, exciting and long-term challenges for the research community. The UK has an opportunity to develop its reputation in key areas of global importance for the long term. In parallel, there is the opportunity to raise the public profile of science and engineering, showcasing its central role in solving global problems, its contribution to the economy and the prospect of exciting and fulfilling careers. The excitement over the competition to decipher the human genome in the 1990s (see Box 5.3) and the race to find the solution to Fermat's last theorem illustrate the way a scientific competition can capture the public's imagination and engage our best scientists and engineers in driving forward a critical area of research. In order to ensure adequate funding for such an approach, further direction of the Research Councils' existing funds towards these critical global climate change goals is likely to be necessary.

Box 5.3: The Human Genome Project

The Human Genome Project was founded in 1990 by the US Department of Energy and the US National Institutes of Health to discover all the genes that make up the human genome. Funding also came from numerous other groups around the world, including the Wellcome Trust in the UK. Originally expected to take 15 years, widespread international collaboration, along with advances in genomics and computing technology, led to an essentially complete genome being announced in 2003, two years earlier than planned. It also prompted a rival attempt by US firm Celera Genomics in 1998 using a different technique, whose competition benefited the project by accelerating progress.

5.50 In order to generate this kind of "buzz" around the long-term challenges relevant to low-carbon cars, and to secure a strong position for the UK, we suggest that the Research Councils consider the following approach:

- the identification of a small number of "CO_2 Challenges", with stretch or step change targets for a 20 year timeframe – an example might be batteries with energy densities an order of magnitude greater than Li-ion. Associated with each Challenge would be a grants programme, encouraging a wide range of approaches to the problem, including developments in fundamental science and "high risk" approaches; and
- each Challenge would be associated with a regular international conference, perhaps every two years, where groups from around the world would be invited to come and present papers on how close they were to the target and the related science and technology developments. These meetings would be designed to generate the excitement of a race, capturing the attention of researchers from different disciplines as well as the wider public, and stimulating media interest. At each meeting there could be a prize for the closest approach to the long-term target or the most innovative development, as assessed by an eminent panel chaired by a Nobel Prize winner. International collaboration would also be encouraged.

5.51 Potential areas for such "CO_2 Challenges" might include:

- energy storage for mobile applications e.g. batteries, hydrogen storage, capacitors, superconducting storage;
- ultra low-resource intensity biofuel feedstocks, or novel routes to biofuels;
- new routes to the production of sustainable/low-CO_2 hydrogen; and
- rethinking the car: the cars driven today are based on over one hundred years of development of a system with a high energy density liquid fuel burnt in an internal combustion engine. One challenge could be to explore radically difference concepts of the car e.g. what if oil had not existed? Could a car body be made out of the battery – perhaps a composite material which stores energy in a vast area of interfaces?

Recommendation 35: The Research Councils should urgently identify a limited number of critical long-term challenges and focus research efforts and funding around them, exploring innovative approaches to instil a sense of urgency and excitement for the research community and the wider public.

Prizes

5.52 Major prizes have a long history of successfully promoting research into particular technological challenges.[12] Prizes can be highly effective in leveraging investment several times greater than the value of the prize offered. They achieve this through increasing the rewards to successful innovation, as well as signalling areas of research that are highly valued by society. The media attention that often accompanies the announcement and award of prizes is also important in attracting research investment.

[12] *Technology Prizes for Climate Change Mitigation*, Newell, R. & Wilson, N., 2005.

5.53 In the eighteenth century, the British Government sponsored a financial prize to develop an improved method of measuring longitude while at sea, while prizes offered by a Chicago newspaperman played an important role in the development of the automobile industry. More recently, the DARPA Grand Challenge and the Ansari X Prize have received considerable media attention (see Box 5.4 below).

Box 5.4: The Automotive X Prize

The Automotive X Prize challenges competitors to produce an affordable, safe, four-seat family car with the potential to appeal to ordinary buyers. It must be able to achieve 100 miles per gallon, and competitors must produce a business plan to produce 10,000 of these vehicles each year. The final prize has not been formally announced, but a multi million dollar prize has been promised.

The Ansari X Prize was established in 1995 to promote non-governmental space technology and product development. The X Prize Foundation offered a $10 million prize for the first non-governmental organisation to launch a reusable manned spacecraft into space twice within two weeks. SpaceShipOne won the prize in October 2004. The prize was highly effective in leveraging private sector investment and attracted significant media interest. In return for the award of $10 million to the winner, more than $100 million was invested in new technologies in pursuit of the prize.

Given the success of the initial X Prize a number of subsequent X prizes have been announced, including the Automotive prize. Prizes are funded by the X Prize Foundation which is US based non-profit educational organisation supported by contributions from individuals, companies and other organisations.

5.54 While prizes can be successful in leveraging investment in innovation and development (as noted by the Stern Review), it is important to recognise the circumstances in which they should be used. Prizes can divert R&D effort away from other projects and can crowd out other fruitful areas. They may also lead to a significant amount of duplication. Because of this, it is particularly important that prizes encourage the correct innovation and development goals. These are not always easy to define. It is also important that prizes are correctly designed. Factors such as the value of the prize (greater challenges, which incur higher costs and a greater risk of failure, meriting larger financial rewards), ownership of the intellectual property rights for successful entries and judging methods all need to be carefully considered.

5.55 Prizes can have an important role in pulling forward technological breakthroughs. The Review therefore welcomes the announcement of the Automotive X Prize, which aims to promote the development of a highly fuel-efficient vehicle that can be produced for the mass market. While the X Prize is likely to stimulate technology developments in new cars, a significant challenge remains in reducing carbon emissions from the existing car fleet, particularly in developing economies, where vehicles tend to use older technologies, and the fleet is replaced more slowly.

Recommendation 36: The UK Government should explore with other EU countries whether an EU level prize could be developed to find low-cost solutions for retrofitting to existing cars to reduce their emissions by a minimum of, say, 25 per cent.

5.56 There tend to be relatively few UK entries for international prizes because our university and business funding mechanisms are not well aligned to such challenges. The Research Councils and the TSB should look at whether it would be possible for their grant mechanisms to support innovative entries for major international prizes.

Recommendation 37: The Research Councils and the Technology Strategy Board should examine whether it would be possible for their grant mechanisms to support innovative entries for major international prizes.

Using UK influence throughout the world

5.57 Globally there are two overarching challenges for car CO_2 emissions. The first is to reduce emissions from the average car in the wealthiest countries, such as the US and European nations. This can be tackled partly through downsizing and measures to encourage smarter consumer choices, but technology will have a major role to play. The second is to manage CO_2 from increasing car ownership levels in developing and emerging markets. Technology also has a role to play in tackling this second challenge. Low-CO_2 cars currently carry a cost premium and it is vital that cost does not become an obstacle to the take-up of low-CO_2 technology in low-income, highly price sensitive markets.

5.58 The Stern Review set out the role of government in promoting international collaboration to overcome barriers to technological development. The global nature of the challenge and the range of technologies where R&D is needed mean an international approach to developing technologies is beneficial. Through avoiding duplication of research effort and accelerating learning through promoting and formalising knowledge spillovers, collaboration can speed up the innovation process and bring forward technological breakthroughs. It can also spread the risks and disseminate the costs of R&D. Government, industry and research bodies should look for opportunities to forge links with counterparts around the world.

5.59 International collaboration can range from formal multilateral agreements to informal arrangements such as links between universities and research networks. Cooperation can take a number of forms:

- sharing of knowledge and information;
- coordinating R&D priorities across national programmes; and
- pooling risk and reward for major investments in R&D.

5.60 There are many examples of where multilateral frameworks and funding have supported technology development. For example, the Consultative Group on International Agricultural Research (CGIAR), established in 1971, draws together the work of national, international and regional organisations, as well as the private sector, to mobilise agricultural science, promote agricultural growth, reduce poverty and protect the environment. At the European level, the EU's Framework Programme for R&D entered its seventh programme in 2007. As part of this framework, EU Joint Technology Initiatives have been established to implement a common strategic research agenda in a number of different fields.

5.61 International collaboration is imperative if the grand challenges outlined in this chapter are to be met. Clearly, key challenges, such as ensuring the development of low-carbon vehicles in emerging markets such as China and India, cannot be met by the UK acting in isolation. Supranational institutions, such as the European Union, have an important role in ensuring necessary collaboration takes place. But the UK can play a leading role.

Collaboration with developing economies such as India

5.62 India is a rapidly developing economy where, currently, less than 1 in 100 people own a car. The Tata Nano has just been launched, at a price of 100,000 rupees (around £1,275) with the objective of greatly increasing car ownership. However despite being a small car, it is not fuel efficient for its size as the development focus has been predominantly on affordability. From the point of view of combating climate change, getting low-emissions technology into this market early would be a real benefit.

5.63 This also has the potential to be a major opportunity for UK companies, now and for the long term, if steps are taken early. India and China, and other emerging market economies, are the new major markets for the car industry. Small, low-cost cars are also likely to spread rapidly to other fast growing Asian economies where motorcycles are currently the main form of transport for families, such as Vietnam. Developing the relationships now could mean that UK companies are in at the beginning of a huge growth in the emerging market automotive industry, which is already looking to expand into Europe and the rest of the world.

5.64 However, smaller UK companies with innovative automotive technologies see this as a high risk market needing extensive and expensive R&D to cost reduce their current low-emissions technologies and to develop new approaches. Their current priority is to get their solutions into the US and European markets as new emissions legislation is brought in to developed countries.

5.65 A collaborative research, development and demonstration programme between the UK and India, with dedicated funding, run by the TSB as an extension to the LCVIP, with a range of funding partners, could help overcome these barriers. The programme would need to support consortia of UK and Indian companies, potentially involving universities in both countries, working collaboratively to undertake technology development and demonstration, including vehicle demonstration, for "the low-cost, low-emissions car".

Recommendation 38: Government, industry and research bodies should look to forge links with counterparts around the world. More specifically, the Government should work with the Technology Strategy Board and other potential partners including the Research Councils, The British Council and UK Trade & Investment to design and fund a programme to support consortia of Indian and UK companies and universities to develop and demonstrate the "low-cost, low-emissions car".

CONCLUSION

5.66 There are some significant R&D technological challenges to be resolved, as we move towards the decarbonisation of road transport. This chapter has set out a number of opportunities for the UK to play a leading role in a low-carbon future in the area of low-carbon vehicles, and made recommendations for realising these opportunities.

6 Maintaining momentum

6.1 The King Review Part II has set out a number of recommendations for action, to a range of bodies including central and local government, the research community and other non-government bodies. It is striking that there are a significant number of Departments and bodies who need to play their part in bringing about progress in this area, underlining one of the challenges of delivering change. It is important that implementation of these recommendations is taken forward, and that there is a focal point for coordinating efforts and driving progress. The Review therefore recommends that the Department for Transport (DfT) should establish an implementation plan to drive forward implementation of the recommendations and a Steering Group with senior representatives of the other Government Departments who have contributed to this Review (HM Treasury, the Department for the Environment, Food and Rural Affairs (DEFRA), the Department for Business, Enterprise and Regulatory Reform (BERR) and the Department for Innovation, Universities and Skills (DIUS)).

Recommendation 39: The Department for Transport should establish a clear implementation plan for leading progress across Government on the full range of recommendations.

This should be supported by a Steering Group made up of senior representatives of HM Treasury, the Department for Environment, Food and Rural Affairs, the Department for Business, Enterprise and Regulatory Reform and the Department for Innovation, Universities and Skills to provide cross Government support from the Departments that will need to take forward many of the recommendations.

6.2 The recommendations made in this report are important steps in delivering a low-carbon transport future, which in itself is key to the UK's role in tackling climate change. The Review therefore recommends that the Sustainable Development Commission should be asked to report in 12 months time on the progress the Government has made in implementing the recommendations.

Recommendation 40: The Sustainable Development Commission should be asked to report in 12 months time on the progress the Government has made in implementing the recommendations of this Review.

Acknowledgements

CALL FOR EVIDENCE CONTRIBUTORS

The King Review Team would like to thank everyone who responded to the Call for Evidence. We received almost 100 submissions, containing a wealth of interesting evidence and insights to inform the Review.

We have endeavoured to ensure that all individuals and organisations that have made representations to the King Review's Call for Evidence are included below, except those who requested anonymity. If we have made an inadvertent omission from this list, please accept our apologies.

Submissions received from members of the public:

Stephen Harding
Paul Kenny
Deborah King
James Levy
Nicholas Morgan
Ian MacPherson
John Munford
Stephen Plowden & Simon Lister
Richard Schumacher

Submissions received from organisations:

Alliance Against Urban 4x4s
ARUP
Association of British Drivers
Biomethane for Transport
BP
Bryte Energy Ltd
BVRLA
Calor Gas Limited
Carillion plc
Carplus
Cenex
Centre for Narrow Vehicle Research
Centre for Process Innovation Ltd
CSEM-BMP
Dragonfly Hybrids Ltd
Energy Saving Trust
Environmental Industries Commission
E. On
Faraday Advance

Food & Drink Federation
Ford Motor Company
Friends of the Earth
Fuel Cell Today
General Motors UK & Ireland
Geotech Resources Ltd
Greater London Authority
Greenpeace
Green Plus Ltd
GreenSpeed
Imperial College
Institution of Mechanical Engineers
ITM Power plc
Lancaster University
Lotus Engineering
Low Carbon & Fuel Cell Technology Knowledge Transfer Network
LP Gas Association
Lyondell Chemical Europe
Microcab Industries Ltd
The Narrow Car Company
National Physical Laboratory
National Transport Roundtable
Natural England
Natural Gas Vehicle Association
NICE Car Company
OXFAM GB
Oxonica
Provecta Car Plan Ltd
RAC Foundation for Motoring Ltd
Research Councils UK
Ricardo UK Ltd
Royal Society of Chemistry
Royal Society for the Protection of Birds
Shell International Ltd
Society of Motor Manufacturers & Traders
Sustainable Consumption & Production Taskforce
Sustraco Ltd
SUSTRANS
Technology Transition Corporation
The Business Project Office
The Greenfuel Company Ltd
The Hardstaff Group
The Slower Speeds Initiative
Trafficmaster plc
UK Energy Research Centre
Unilever UK Limited
United Kingdom Hydrogen Association
University of Herefordshire
University of Strathclyde

CONTRIBUTORS WHO SHARED INSIGHTS THROUGH MEETINGS AND OTHER COMMUNICATIONS

Advanced Composites Group
Advanced Transport Systems
Advantage West Midlands
AEA Technology
Association of Car Fleet Operators
Automotive Green Developments
Axon Automotive
Biotechnology and Biological Sciences Research Council
BMW
British Consulate General – San Francisco
Cabinet Office
California Air Resources Board
California Fuel Cell Partnership
Chevron
Clean Air Power Ltd
Commission on Environmental Markets and Economic Performance
Confederation of British Industry
Department for Business, Enterprise and Regulatory Reform
Department for Children, Schools and Families
Department for Environment, Food and Rural Affairs
Department for Innovation, Universities and Skills
Department for Transport
Driving Standards Agency
E4tech
East Midlands Development Agency
Economic and Social Research Council
Element Energy
Energy Foundation
Energy Technologies Institute
Engineering and Physical Sciences Research Council
Ensus Ltd
European Commission
Federation International de L'automobile
Gasrec Ltd
Going Green
Hardstaff Group
Her Majesty's Treasury
Institute of Materials, Minerals, and Mining
Intelligent Energy
International Energy Agency
Jean-Francois Larivé
Johnson Matthey
Lotus
LowCVP (Low Carbon Vehicle Partnership)
Lysanda Carbon Emission Control Technology

Modec
Motorsport industry association
National Express
National Non-Food Crops Centre
Natural Resources Defence Council
Nissan Motor (GB) Limited
Office of Climate Change
Pacific Gas & Electricity
Smith Electric Vehicles
Sovereign Strategy
Technology Strategy Board
The International Council of Clean Transportation
Torotrak
Toyota
Trade Union Congress
Transport for London
University of California, Berkeley
University of California, Davis
Virgin Fuels
Volvo
UK LPG (UK Liquid Petroleum Gas)
UK Petroleum Industries Association
Union of Concerned Scientists
Unite-Amicus
Western States Petroleum Association
Zytek

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